# New York State Museum Bulletin

Published by The University of the State of New York

No. 276 ALBANY, N. Y. June 1928

## New York State Museum

Charles C. Adams, Director

# THE CHILOPODA OF NEW YORK STATE WITH NOTES ON THE DIPLOPODA



BY

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# THE CHILOPODA OF NEW YORK STATE WITH NOTES ON THE DIPLOPODA

BY

JOHN WENDELL BAILEY Ph.D.

## INTRODUCTION

The Chilopoda (centipedes) and Diplopoda (millipedes) form two very distinct classes under the Phylum Arthropoda.

Formerly these two classes, with the Pauropoda and Symphyla, were grouped together as a single class, the Myriapoda. This grouping has been abandoned. As a matter of fact the agile, carnivorous Chilopoda, with one pair of legs to each segment of the body, have a much closer affinity with the true insects than do the slow moving, vegetable feeding Diplopoda, with two pairs of legs to each body segment.

The Pauropoda and Symphyla are both very distinct from the Chilopoda, on the one hand, and from the Diplopoda on the other.

Chilopoda and Diplopoda are widely distributed, and are represented in almost every part of the globe. Heat and cold alike seem to offer favorable conditions for their existence. They flourish both in the most fertile and in the most barren countries. They are also found in caves.

With a few rare exceptions, members of these groups do not exercise any direct influence upon human affairs as do the insects and some members of the other classes of animals. Consequently they have not attracted any great amount of attention from the naturalist. It is true, however, that some species of Chilopoda (*Scolopendra*)

may be harmful to man on account of their poisonous bite; also some species of Diplopoda (*Diploiulus*) are credited with destroying certain crops.

*Diploiulus londinensis coeruleocinctus* (Wood) is the cause of many complaints from growers of truck crops throughout the eastern portion of the United States and many times New York fruit growers have charged this species with injuring apples during the picking and packing season. As a matter of fact, *Diploiulus* attacks only the bruised fruits with broken skins. The imported " greenhouse millipede," *Orthomorpha gracilis* (Koch), while almost universally present in greenhouses, has never been proven to be injurious to plant life. In California *Scutigerella immaculata* (Newport), a member of the class Symphyla, has been shown conclusively to be one of the most destructive pests known to attack asparagus and other truck crops in that state (Wymore, 1924, p. 73–88).

## NUMBER OF DESCRIBED SPECIES

The extent of the wide distribution of the various species of Chilopoda and Diplopoda, in different countries, may be attributed to the ease with which they are introduced into a country in the earth and packing around plants, and in boxes of fruits and supplies.

The known number of the species in the United States in 1885 was as follows: California, 27; Pennsylvania, 25; Illinois, 16; Georgia, 13; Oregon, 12; Virginia, 10; Texas, 8; New York and Florida, 7 each; Michigan, 5; Louisiana and Tennessee, 4 each; Massachusetts and Kentucky, 3 each; Connecticut, New Jersey, Indiana, North Carolina and Missouri, 2 each; New Hampshire, Rhode Island, Maryland, District of Columbia, Alabama, Mississippi, Minnesota, Arkansas, Kansas, Colorado, Utah, New Mexico and Washington 1 each; the total number of species of the Chilopoda and Diplopoda being 126. These species represented 15 genera of Diplopoda and ten genera of Chilopoda. At the same time there were 170 species of Diplopoda and Chilopoda known to occur in Austria Hungary.

At the present writing (August 1926) there are approximately 6000 described species of Chilopoda and Diplopoda in the world, fully 2000 species being known from North America alone. These figures are based upon careful estimates after counting the species listed in the literature on these groups in the library of the Museum of Comparative Zoology, Harvard University, Cambridge, Mass.

The New York list, as noted on page 19 of this paper, includes 23 species of Chilopoda representing 19 genera. The number of Diplopoda, 31 species, includes 19 genera. No doubt additional collecting from time to time will reveal the presence of many more species of these two classes.

Like all other members of the Phylum Arthropoda, both the Chilopoda and the Diplopoda have segmented bodies and segmented appendages. In common with each other, they have elongated bodies presenting two main divisions; head and trunk, or body proper, and numerous pairs of legs. Aside from these characters the two classes are quite different and will be discussed in separate paragraphs.

## THE CLASS CHILOPODA

In the class Chilopoda the body is relatively long and ribbon-shaped, being compressed dorso-ventrally. The antennae are large and flexible and consist of 14 or more segments. They have one pair of six or seven segmented legs to each body segment. The legs are inserted at the sides of the body and are widely separated by the large sternal plates (figure 1). The genital ducts open on the posterior region of the body, usually on the preanal segment. The appendages of the first body segment are jawlike and function as organs of offense, the poison jaws. They are often spoken of as the prehensorial feet or toxicognaths (figure 2). These toxicognaths consist each of six segments, of which the coxa or basal one is usually fused with the next segment, the two forming a large coxal plate; the third, fourth and fifth segments form a strong hingelike connection between the first and second and the sixth segment or the piercing fang. There appears to be an opening in the claw through which a poison duct leads from the poison gland which is situated in the first body segment. The head bears one pair of mandibles (figure 3), and two pairs of maxillae (figure 5). The maxillae are foliaceouslike structures and are usually regarded as biramus. The second pair of maxillae are sometimes known as palpognaths. They are leglike in form, consisting of five or six segments and as a rule the coxae are united on the median line of the body as shown in figure 5-*b*. Eyes may be either absent or present, but when present they consist of numerous ocelli. In a few species the ocelli are agglomerated or pseudofacetted. The legs are made up of six segments, the terminal segments or tarsus being armed with a single terminal claw. The last two legs are directed backward, and are often greatly modified in form. Upon these modifications are based many generic and specific characters.

There are two subclasses of Chilopoda, Pleurostigma and Notostigma. The former have the spiracles arranged in pairs and situated

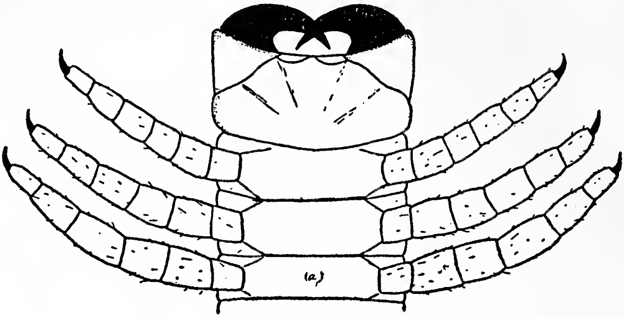


Figure 1 Ventral aspect of anterior portion of an adult centipede (Chilopoda) showing three body segments with one pair of legs attached to each segment and the sternal plate (a).

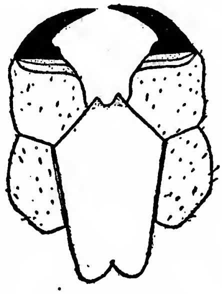

Figure 2 The prehensorial feet or toxicognaths of a centipede, *Geophilus* species.

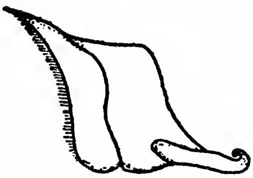

Fig. 3 Mandible of a centipede, *Geophilus* species.

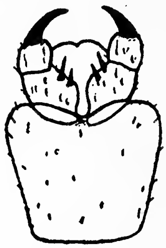

Figure 4 Terminal segment of a female *Lithobius* showing the hooks used during the egg laying period.

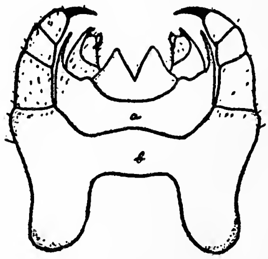


Figure 5 Maxillae of a centipede. (a) Fused base of the first or true maxillae. (b) Palpognaths or second maxillae fused together.

in the sides of the segments that bear them (figure 6), while the latter have the spiracles opening in the middle of the back, each in the hind margin of one of the seven prominent terga or segments of the body region (figure 7).

## Habits of the Chilopoda

All of the Chilopoda are terrestrial forms and most of them are very sensitive to conditions of moisture. Consequently in the arid and semiarid regions like the Middle West, Texas, New Mexico, Arizona and parts of California, many forms burrow into the ground during the extreme dry seasons, and their presence is rarely if ever revealed to any other than the energetic collector. As a group the Chilopoda are less distinctively tropical than the Diplopoda. They are, however, more tenacious of life than the Diplopoda. Chilopoda are all carnivorous and very active. Their food consists mostly of insects and other small animals encountered in their habitat.

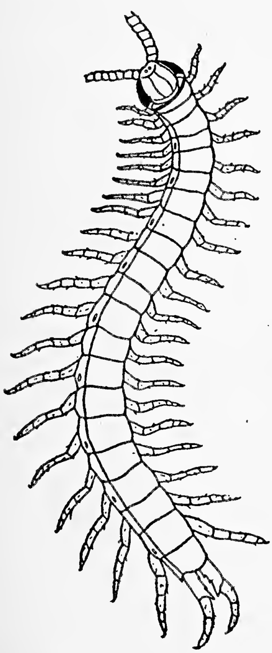

Figure 6 A true Chilopod (centipede, *Scolopendra* species) showing the pleurostigma or spiracles arranged in pairs on the sides of the body segments.

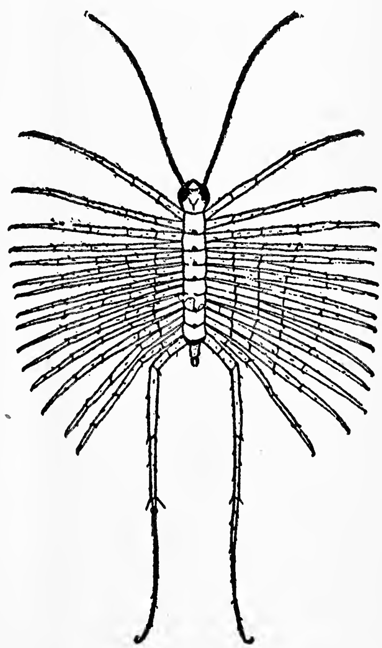

Figure 7 A centipede of the subclass. *Notostigma,* showing the spiracles opening in the middle of the back in a single series (*Scutigera* species).

In discussing the life history and breeding habits of Chilopoda it will be necessary first to discuss, briefly, the special auxiliary sexual characters of the female of one of the species whose breeding habits have been observed. In Lithobius, the female is provided with two small moveable hooks, on the under side of the terminal segment of the body close to the opening of the oviduct (figure 4). These hooks play an important part in the proceedings following the laying of the egg.

*Lithobius* breeds usually from June through August, and it is not uncommon to find several sizes of young in the same locality at the same time. Concerning the deposition of the egg of this genus one investigator says:

> There are first of all some convulsive movements of the last segments of the body, and then in about ten minutes the egg appears at the entrance of the oviduct. The egg is a small sphere (about the size of a number five shot) rather larger than that of Julus, and is covered with sticky slime secreted by the large glands, inside the body, usually called the accessory glands. When the egg falls out it is received by the little hooks and is firmly clasped by them. This is the crucial movement in the existence of Lithobius into which the egg is to develop. If a male Lithobius sees the egg he makes a rush at the female, seizes the egg, and at once devours it. All of the subsequent proceedings of the female seem to be directed to the frustration of this act of cannibalism. As soon as the egg is firmly clasped in the little hooks she rushes off to a convenient place away from the male, and uses her hooks to roll the egg round and round until it is completely covered by earth, which sticks to it owing to the viscous material with which it is coated; she also employs her hind legs, which have glands on the thighs (coxae) to effect this purpose. When the operation is complete the egg resembles a small round ball of mud, and is undistinguishable from the surrounding soil. It is thus safe from the voracious appetite of the male and she leaves it to its fate (Sinclair, 1895, p. 38).

A single *Lithobius* rarely if ever deposits more than 15 to 30 eggs in one litter or complement. It is thought, however, that she may deposit more than one complement of eggs during a breeding season. The eggs hatch in from two to five weeks, depending upon the temperature. In most cases the young when hatched have their full number of legs, but in others only a small number of legs, usually seven pair in Lithobius, are present and fully developed.

## THE CLASS DIPLOPODA

The body of Diplopoda is round or nearly so, with two pairs of legs to nearly all the body segments. The genital ducts are paired and open on the anterior ventral region of the body, behind the second pair of legs. In the male there is usually an external copulatory organ at the base of the seventh pair of legs, remote from the genital openings. The auxiliary organ is a modification or trans-

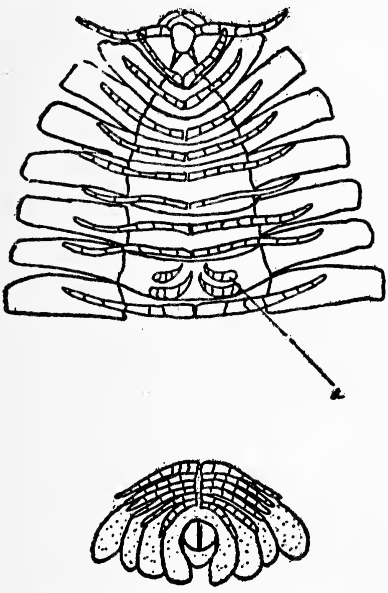

Figure 8 Showing the legs of the seventh segment modified into external copulatory organs (*Platydesmus* species).

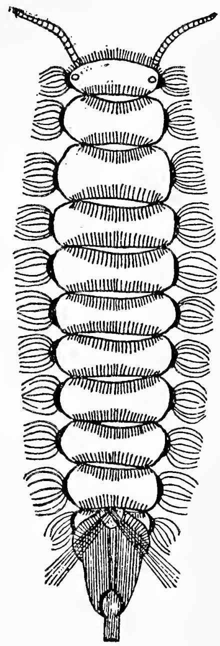

Figure 10 *Polyxenus fasciculatus* Say showing the arrangement of the spines on the body.

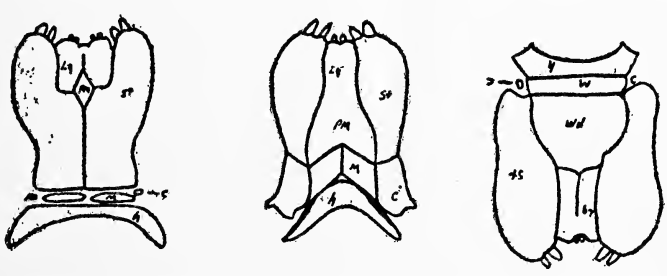

Figure 9 The gnathochilarium or second jaws of representative Diplopod. (c) cardo; (h) hypostoma; (lg) liguae; From Comstock after Silvestri.

formation of one or both pairs of the legs of that segment (figure 8). The antennae are short and very similar to the legs.

The apparent doubling of the appendages on the body segments is due to the grouping of the segments in pairs and either a consolidation of the two terga of each pair of segments or the nondevelopment of one of the terga. Investigators are divided as to which of the two alternatives is correct. That there has been a grouping of the segments in pairs where the segments are doubled is quite evident. Corresponding with each tergum there are two sterna and two pairs of spiracles. Usually the first three or four and the last one or two segments have only one pair of legs each. Sometimes one of the anterior segments is legless.

The head bears the mouth parts, the eyes and the antennae. The eyes, although sometimes absent, usually are represented by a group of ocelli on each side of the head. The antenna is a short, leglike structure consisting usually of seven segments. The mouth parts are made up of a pair of mandibles, an upper lip and a gnathochilarium, which in turn consists of a pair of jaws united at the base, forming a large plate (figure 9). In some species of Diplopoda the mandibles are vestigial, while in others they are well developed, consisting of several parts and excellently fitted for biting.

## Habits of the Diplopoda

Diplopoda are inhabitants of damp places and may be found under stones, planks, in rotten timber, or in fallen leaves, moss or the like. Some species have been collected from caves. They feed mostly on decaying vegetable matter; but some species feed on growing plants. About the only means of defense that the Diplopoda possess is their ability to give off an ill-smelling liquid, which is expelled from the body through a series of pores (glandulae odoriferae) opening on many of the body segments. This fluid resembles a fine quality of oil in appearance but it contains a goodly amount of prussic acid.

The family Polyxenidae has a soft body covered with spines; the copulatory feet are absent and the mandibles are one-jointed. Members of this family defend themselves by means of the stiff spines or bristles that cover the body. Viewed from any angle, members of this family have a very warlike appearance, (figure 10). As this means of defense seems to have been more common among fossil Diplopods than among those still living it is apparent that this little *Polyxenus* is probably the oldest type of living Diplopod. Certainly it is the most unique and interesting member of the group. The life

history of a typical Diplopod may be taken from the universally common genus, Julus.

*Julus* breeds in May, June, July and August in the southern portion of the United States (in Mississippi), and in July and August in New York State. Just prior to the deposition of her eggs the female constructs a sort of nest or alcove in which she places her eggs. This nest is made by the animal burrowing down a few inches into the soft earth and constructing a small hollow sphere of numerous tiny pellets of earth which she works up into convenient sizes and shapes with her jaws and front legs. She moistens these bits of earth with a sticky fluid secreted by her salivary glands, which during the breeding season becomes very active. The inside of the nest is always smooth, while the outside is rough or honeycomblike, showing clearly the shape of the small pellets of earth used in its construction. The completed nest is about the size of a large marble. The eggs are placed in the nest through a hole which is purposely left in the top. A vigorous female *Julus* will deposit as many as 100 eggs in a nest. Each egg is white and is covered with a gelatinous fluid and the entire mass sticks together. After depositing the eggs in the nest the female closes the hole, with the same material used in the construction of the nest, and leaves it, never to return. If not disturbed, under normal conditions, the eggs will hatch in about two weeks. The young upon leaving the egg possess only three pairs of appendages; one pair of antennae and two pairs of indistinct mouth parts. Only a few of the body segments are present. The legs are added in groups of five pairs at a time, the addition of body segments and legs being made between the penultimate and the ultimate segment. They are not, as commonly thought, added to the end of the body.

*Polydesmus* makes a nest and deposits its eggs very much like *Julus*. The time of breeding is during the spring and early summer, and the period of incubation ranges from ten to 20 days, depending upon the temperature.

*Spirobolus,* one of the most common and the largest of the Diplopoda found in New York State, deposits its eggs in damp, wet places, usually in some decaying stump or fallen log. The pearly white eggs, about the size of a small buckshot, are deposited in June, July and August; usually 15 to 20 in a batch. The eggs are never covered with dirt, as in Julus or other species. The period of incubation is said to be ten to 18 days. The young emerge from the eggs as partially developed larvalike creatures having only three pairs of appendages as do other members of the class Diplopoda.

## COMMON NAMES

Centipedes and millipedes are the common names applied to this group of animals by the English-speaking people of the world. The Frenchman calls them "millipedes" and the Germans speak of them as "tausendfüsse." These terms merely imply the possession of numerous legs. The Danish call the centipedes "lufindbeen" and the millipedes "kielderorme," but they mean 100 legs or 1000 legs respectively. The Spanish use the word "cientopies" to designate the 100 legs or centipedes. The Persians call them "hazarpa," which means thousand feet; also they use the term "sadpa," or hundred feet and "Chelpa," forty feet. The peasants in the eastern countries also call them "forty legs." The Arabs call them "Arba Wal Arbarin," forty-four legs. As a matter of fact, the Scolopendras, which in the hotter climates are the chief representatives of the centipedes, have actually 42 true legs, or, if the prehensorial legs (poison claws) are counted, 44. Some genera have 46 legs, or, if we count the prehensorial legs or poison claws, 48. The Chinese use an expression for centipede which, using the English spelling and pronunciation, would be "Woo-Kong."* Their interpretation is that the animal has 100 feet, and the name for it is intended to convey that impression.

## PALEONTOLOGY

According to the paleontological history of the world, the Chilopoda and Diplopoda are among the oldest animals of the earth. The oldest known fossils of these groups are those from the lower, Old Red sandstones of Scotland, which were laid down in the Devonian formation of the Paleozoic period. Two species of Archipolypoda have been found in the Devonian formation (Scudder, 1885, p. 245). That these animals are among the antiques of the animal and plant kingdom is clearly understood when we realize that such ancient animals as the corals, sponges, starfishes and fishes made up the highest known animal life of the time. Then in the plant kingdom there were the algae, ferns and conifers. All these forms have been found fossilized along with the early Archipolypoda, showing conclusively that they were all present on the earth at the same time.

In the Carboniferous beds (Paleozoic period) 32 species of Archipolypoda (Diplopoda) have been found. These forms represent

* This term, spelling and pronunciation were given to me by a Chinese student attending Harvard University during the summer of 1925.

the next oldest of the group known. Most of these are American forms and are classified under the Archipolypoda. Four questionable species of this same group are recorded from the Dyas period. From the next period, the Lias (Mesozoic era) no fossils of this group have been found, but in the Jurassic and Cretaceous periods a questionable species of the true Chilopoda and Diplopoda respectively have been found. The Eocene period of the Cenozoic era has not as yet yielded any species of these groups.

During the Oligocene period at which time the plants and animals were represented by many forms, some of which were beginning to become specialized, the true Chilopods and Diplopods came into their own, so to speak. Scudder records 17 species of Chilopods and 23 species of Diplopods from this period.

The Miocene period has produced only one species thus far, a Diplopod, while the Pliocene and modern periods show us traces of fossil Chilopoda or Diplopoda. With the exception of the Diplopod family Polyxenidae, the modern Chilopoda and Diplopoda do not resemble the fossil forms to any appreciable extent. As a general rule, as we proceed toward the species found in the more recent strata we find them more and more like the ones living at present. But members of the family Polyxenidae resemble, very strikingly, the fossil of the Old Red sandstones in Scotland. They are armed with numerous spines both " fore and aft," and in many ways resemble the early fossil forms.

## HISTORICAL ACCOUNT

The systematic study of the Chilopoda and Diplopoda is a difficult problem. Most of the literature on the group is fragmentary and scattered, and the animals, though quite harmless, are generally avoided by all except the most zealous collectors.

In so far as can be ascertained from the bibliographies and indexes available, there have been approximately 2489 papers and volumes published on these groups. Of this number 421 relate to North American forms. Six hundred fifty-two investigators have published the results of their labors, 82 having published on North American forms. In this paper no attempt is made to go into detail regarding the literature on the subject. Only casual mention is made of foreign papers, and then only those are mentioned in which North American species are discussed. Of the American papers only the most important are discussed, some of which are listed in alphabetical order by authors in the appended bibliography.

As may be seen from the appended list, nothing with the exception of a few general remarks contained in some of the papers refer to New York State species. To the knowledge of the writer there has never appeared a New York State list or a key to the New York forms of Chilopoda or Diplopoda, or even a discussion of the groups.

The earliest mention of any of these groups of animals, as noted by some writers, is the supposition that the word which is translated "mole" in the Bible (Lev. XI, 30) is really Scolopendra, a genus of Chilopoda. In classical times, Aelian (Book XV, A. D. 200) says that the entire population of a town called Rhetum, in Crete, was driven out by a swarm of Scolopendra. Also Pliny (A. D. 77) mentions a marine Scolopendra, which in all probability was a species of marine worm. Lister and Palmer in volume VIII of their work entitled A Journey to Paris in the Year 1698, which was published in London in 1899, mention having observed Scolopendra on their journey. In the Methodus Insectorum published in London in 1705, John Ray mentions this group of animals under the title of "Insecta Polypoda Terrestria." Ray (1710), in collaboration with Lister, published accounts of the centipedes and millipedes in the Historia Insectorium, (London) under the title of "Insecta Pedibus Plurimus." Carolus Linnaeus (1735–68) in his Systema Nature classified the Chilopoda and the Diplopoda as "Insecta Aptera." He gave them the generic names "*Scolopendra*" and "*Julus*," respectively. In 1743 he listed nine species of *Scolopendra* and seven of *Julus*. The writers for many years after Linnaeus continued to classify these animals with the insects, spiders and scorpions, and in some instances with the serpents. P. A. Latreille in 1796 established the name "Myriapoda" for this group of animals (1796, p. 199–201). In so doing, however, he grouped the Crustacea along with the Myriapoda, and called the two groups class Myriapoda. The class included five genera; three genera of Crustacea; *Aselle* (Asellus), *Cyame* (Cyames) and *Cloporite* (Cloporius); and two genera of Myriapoda; *Scolopendra* and *Julus*. All were classified under the insects. Latreille (1810, p. 105–35) grouped part of the Crustacea, the spiders and the Myriapods together under the class Arachnides, leaving the insects to themselves. In 1814 W. E. Leach presented a paper entitled A Tabular View of the External Characters of Four Classes of Animals Which Linnaeus Arranged under Insecta, in which he made clear the distinction between the Crustacea and the Myriapoda which had been classified by Latreille, as insects (1815, p. 307–76). In separating

the Myriapoda from the insects and Crustacea, Leach retained the name Myriapoda and raised it to the distinction of a class. Under this class he listed two orders, *Scolopendra* and *Julus*. These two orders contained five families, nine genera and 25 species. The two orders have since been relegated to the rank of genera. In 1817 Latreille, after a very careful study of the group, separated the members having only one pair of legs to each body segment from those having two pairs to each segment. To the group having only one pair of legs to the segment he gave the name Chilopoda (1817, p. 155), and gave them the rank of an order. H. D. Blainville and P. A. Latreille in 1844 established the order Diplopoda and included those Myriapodes possessing two pairs of legs to most of the body segments. Sir John Lubbock in 1870 described " a new centipede " and placed it in a new genus. Pauropus, establishing the order Pauropoda for it (1870, p. 181). The fourth order to be established in this class was Symphyla, described by J. A. Ryder (1880, p. 375). These orders have since been designated as distinct classes and most investigators now regard them as such.

Notice should also be made of the splendid paper by M. Paul Gervais, published in 1847 in which he gave perhaps the fullest and most accurate account of the " Myriapodes " up to that time. Although placing them under the general group of " Insectes Apteres " he recognized two classes, Chilopoda and Diplopoda. His paper is very exhaustive, covering 330 printed pages with seven splendid plates.

## HISTORY IN NORTH AMERICA

Although scattering species had already been described by a few European naturalists, the first note on North American Chilopoda or Diplopoda to be printed in North America appeared in the Annals of Nature, by C. S. Rafinesque (1820). This note described the common house centipede, *Selista forceps* (now *Scrutigera forceps*). Thomas Say published the results of his studies in the Journal of the Philadelphia Academy of Science (1821, p. 23–32). In this paper he described 18 species, mostly from the Southern States, which he arranged in the genera *Julus, Polydesmus, Cermatia, Lithobius, Cryptops* and *Geophilus*. His work is really the first American publication of importance as it recognizes many species.

Since Say's time (1821) 420 papers have been published on North American forms. Special mention should be made of the papers published by H. C. Wood jr, (1861–67), which up to his

time was the most extensive series published on this group by a single individual. After Wood's paper the next of importance came from Charles H. Bollman. Fifteen papers were published by Bollman before his death July 13, 1889. Later 13 manuscripts were found in his study and the entire number were grouped into one publication and issued by the Smithsonian Institution of Washington, D. C. (Bollman, 1893).

Samuel H. Scudder has written much on the fossil Myriapoda (from 1868 to 1890) but very little has been published in North America on the anatomy, morphology and development of the animals.

O. F. Cook, curator of Myriapoda at the United States National Museum, has published several papers on Chilopoda and Diplopoda.

R. I. Pocock has published several papers on North American Chilopoda and Diplopoda. Although his chief work on North American forms dealt primarily with Mexican and Central American species, it included many forms common in the United States.

Unquestionably the most thorough and voluminous work on these groups has been done by Ralph V. Chamberlin, formerly of the Museum of Comparative Zoology, at Harvard University, now at the University of Utah, Salt Lake City, Utah. Chamberlin's work on this group includes more than 80 published papers, some of which are complete monographs of families and genera. His work has not been confined to North American species, but his most important studies have been on North American forms. His first paper on the group appeared in 1901, and since that time he has devoted the greater portion of his time to these groups (1901, p. 21–25).

There are many others who have studied these animals and published their observations from time to time, but no others, so far as the writer is able to ascertain, have devoted any great amount of time to the Chilopoda and Diplopoda.

A list of some of the most important papers dealing with North American Chilopoda and Diplopoda is given at the end of this paper. While it is hoped that the list is complete and accurate, it is hardly probable that it is. Often important papers are published privately or in some obscure magazine and their existence is very often unknown for years to persons outside of the vicinity in which they were published.

## MATERIAL STUDIED

The material studied (about 7200 specimens) in the preparation of this paper may be found in the collections of: Cornell University Entomological Museum, Ithaca, New York; New York State Museum, Division of Zoology, Albany; Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; Museum of Zoology, Mississippi Agricultural and Mechanical College, Starkville; and the Museum of Natural History, Mississippi College, Clinton, Mississippi. By far the greater number of specimens were collected by F. C. Paulmier for the New York State Museum, during the years 1903, 1904 and 1905. The writer collected throughout the State of New York in 1915 and 1916 and in 1924 and 1925.

No mention is made of species merely "thought" to be found in New York State. Only those species that have actually been collected in the State and properly labeled as to locality, date of collection and collector are listed. The list is as follows:

## LIST OF CHILOPODA AND DIPLOPODA KNOWN TO OCCUR IN NEW YORK STATE

### Chilopoda

1 *Arenophilus bipuncticeps* (Wood)
2 *Bothropolyps multidentatus* (Newport)
3 *Cryptops hyalinus* Say
4 *Escaryus liber* Cook & Collins
5 *Escaryus urbicus* (Meinert)
6 *Geophilus deduceus* Chamberlin
7 *Geophilus mordax* Meinert
8 *Geophilus rubens* Say
9 *Linotaenia chionaphila* (Wood)
10 *Linotaenia fulva* Sager
11 *Lithobius forficatus* (Linnaeus)
12 *Nadabius aristeus* Chamberlin
13 *Nampabius fungiferopes* (Chamberlin)
14 *Nampabius lundii* (Meinert)
15 *Otocryptops sexspinosus* Say
16 *Pachymerium ferrugineum* (C. L. Koch)
17 *Paitobius exiguus* (Meinert)
18 *Schendyla nemorensis* C. L. Koch
19 *Scutigera forceps* (Rafinesque)
20 *Sonibus numius* (Chamberlin)
21 *Sonibus parvus* Chamberlin
22 *Sozibus providens* (Bollman)
23 *Zygethobius species*

### Diplopoda

1 *Brachyiulus pusillus* (Leach)
2 *Callipus lactarius* (Say)
3 *Cleidogona caesioannulata* (Wood)
4 *Conotyla fischeri* Cook & Collins
5 *Diploiulus londinensis coeruleocinctus* (Wood)
6 *Diploiulus luscus* (Meinert)
7 *Fontaria corrugatus* (Wood)
8 *Fontaria trimaculata* (Wood)

9 *Julus hortensis* (Wood)
10 *Julus virgatus* (Wood)
11 *Lysiopetalum albus* (Cook)
12 *Nopoiulus minutus* (Brandt)
13 *Ophyiulus pilosus* (Newport)
14 *Orthomorpha gracilis* (C. L. Koch)
15 *Parajulus canadensis* (Newport)
16 *Parajulus immaculatus* (Wood)
17 *Parajulus impressus* (Say)
18 *Parajulus pennsylvanicus* (Brandt)
19 *Polydesmus canadensis* (Newport)
20 *Polydesmus moniliaris* C. L. Koch
21 *Polydesmus serratus* Say
22 *Polydesmus testi* Bollman
23 *Polyxenus fasciculatus* Say
24 *Polyzonium rosalbum* (Cope)
25 *Scytonotus granulatus* (Say)
26 *Scytonotus nodulosus* (C. L. Koch)
27 *Spirobolus marginatus* (Say)
28 *Trichopetalus* (species)
29 *Trichopetalum album* Cook & Collins
30 *Underwoodia polygoma* Cook & Collins
31 *Underwoodia iuloidea* Horger

## COLLECTING AND PRESERVING CHILOPODA AND DIPLOPODA

In collecting Chilopoda and Diplopoda no special apparatus is necessary. Ordinary small forceps, used in general biological work, will prove useful in drawing specimens from their hiding places in crevices of bark or rotten wood, or from débris such as dead leaves and sphagnum. Specimens should be placed immediately in a cyanide bottle or in vials containing 25 to 50 per cent alcohol. If they are placed in alcohol immediately after capturing, it will be necessary to change the alcohol after the specimens have become soaked and cleaned. They are sure to cling to particles of dirt and trash which will, of course, be collected with them. Placing the specimens in the cyanide bottle first is the better method. After a few days in the alcohol the specimens should be taken out and straightened and allowed to dry in that position before being restored to their respective vials. This gives a better opportunity to study the ventral side of the specimen, something that is very difficult to do when the specimens are coiled or partially so. In addition to the regular hand lens, one engaged in the identification of the animals should have a good binocular microscope and also a high power microscope. In studying some species it will be found necessary to use an oil immersion lens to distinguish certain features of the mouth parts.

As a means of encouraging the collection of Chilopoda and Diplopoda in New York State, analytical keys and notes intended to facilitate diagnosis of the species of Chilopoda are included in this paper. Characters of difficult determination are figured for the convenience of those interested in identifying New York forms.

## KEYS TO GROUPS AND DESCRIPTIONS OF SPECIES

### Key to the Arthropod Classes, Diplopoda and Chilopoda

*A* Body typically cylindrical or deep dorso-ventrally; legs attached close together; two pairs of legs to most segments; genital ducts open on the anterior ventral region of the body (Mostly the second segment)

Class DIPLOPODA (Blainville & Latreille)

*AA* Body typically compressed dorso-ventrally, one pair of six or seven jointed legs to each body segment, being inserted at the sides of the body and being widely separated by the large external plates; genital ducts open on the posterior region of the body (usually on the preanal segment)

Class CHILOPODA Latreille

### **Chilopoda** Latreille

(Le Regne Animal Par Curvier, 1817, 3:155)

In addition to the characters given in the preceding key to the classes, the Chilopoda possess many characters that serve further to distinguish them from the Diplopoda, with which they have so long been associated. Some of these characters are as follows: The antennae are long and threadlike or cylindrical, rarely club-shaped or flattened, composed of 14 (rarely if ever 12 or 13) or more segments. Eyes are not always present but when present they consist of from one to many single ocelli. These ocelli are rarely agglomerated or falsely facetted. This class includes two very distinct subclasses; Pleurostigma and Notostigma. This division is based on the difference in the position of the spiracles on the body.

The subclass Notostigma includes only the order Schizotarsia, a type of centipede in which a very distinctive type of respiratory organs are present. Instead of the customary pairs of spiracles as found in the true centipedes and insects, these creatures have only a single spiracle in each of the seven spiracles bearing segments (figure 7). These spiracles open on the dorsal surface of the scuta, each in the hind margin of its respective terga. " These spiracles lead into a short sac from which the tracheal tubes extend into the pericardial blood sinus " (Comstock, 1925, p. 22).

In the Pleurostigma, or true centipedes, the spiracles are paired and are situated in the sides of the segments on which they are borne (figure 6). This subclass includes two known North American orders; Anamorpha and Epimorpha; the distinguishing characters being given in the following key to the orders of Chilopoda:

## Key to the Orders of Chilopoda

*A* Tracheae opening through seven unpaired spiracles arranged along the median dorsal line; antennae very long and many jointed; ocelli of eyes agglomerated or falsely facetted
Order SCHIZOTARSIA Brandt

*AA* Tracheae opening through paired spiracles in the pleural region between tergite and coxae of a variable number of the body segments; antennae and legs moderate or short; ocelli of eyes not agglomerated or falsely facetted

*B* Trunk with 15 leg-bearing segments among which the tergites of the second, fourth, ninth, eleventh and thirteenth are shortened, or reduced; young born with seven pairs of legs, subsequently acquiring the full number through several distinct steps or stages
Order ANAMORPHA Haase

*BB* Trunk with 21 or more leg-bearing segments, among which the tergites of none are relatively reduced or shortened; young hatched (or in some cases born) with the full number of legs
Order EPIMORPHA Haase

### Order **Schizotarsia** Brandt

(Recueil de memoires relatif a'l'ordre des Insectes, Myriapodes, Extract der Bul. Scientif de l'acad. Imper des Sciences de St Petersbourg, V, VI, VII, VIII, et IX, 1841)

The order Schizotarsia includes only the family Scutigeridae, characterized by its large head, with its surface rough and uneven; and the compound eyes, which are set prominently. The scuta are eight in number and the segments 16.

### Family **Scutigeridae** Gervais

(Ann. d. Sc. Nat. 2, ser. 1837, 7:48)

Only one genus, Scutigera of this family is known to occur in New York State.

### Genus **Scutigera** Lamarck

(Systeme des animaux sans Vertebres, ou tableau gen classes, der orders et d. geneus de ces anim. Paris, 1801, p. 182)

The genus Scutigera includes one known valid North American species, *C. forceps,* which was described by Rafinesque in 1820. Chamberlin (1920, p. 283) says that this species is "probably not specifically distinct from *Scutigera coleoptrata* Linné of Europe."

### **Scutigera forceps** Rafinesque

(*Selista forceps,* Rafinesque, Annals of Nature, 1820, No. 1. P. 7. *Scutigera forceps*, Meinert, Ann. Phil. Soc. Phila., 1885, p. 171)

This species, often spoken of as the house centipede, is light brown with three dark stripes down the back, the outer ones being more or less broken. Its body measures about 20–25 mm, the hind pair of legs being twice as long as the body. There are 15 leg-bearing segments in the body region, but the terga of these segments are reduced to seven, by fusion and suppression. The spiracles, seven in all, open in the middle of the back (figure 7). This species is very beneficial to man and inhabits his house, where it continually searches for flies and other insects that annoy man. A single specimen of this species destroys many flies each day during the spring and summer, when the flies are numerous. Although more common in the Southern and Southwestern states this species occurs where it can find comfortable quarters.

**Known New York localities.** Ithaca, May 4 and 12, 1925 (6 specimens) J. W. Bailey, coll.; Albany, October 26, 1906, and February 26, 1907, G. T. Richard and G. H. Chadwick, coll. The writer has also taken this species in Virginia and Mississippi.

### Order **Anamorpha** Haase

(Schlesiens Chilopoden, I. Chilop. Anamorpha, Inaugural Dissent, Breslau, 1880, p. 6)

Members of the order Anamorpha, in addition to possessing the paired spiracles characteristic of the subclass Pleurostigma, are equipped with 15 pairs of leg-bearing segments. The young hatch with only seven pairs of legs, but subsequently acquire the full number through several distinct molts or stages. In North America only one suborder is known to be represented, Lithobiomorpha.

### Suborder **Lithobiomorpha** (Pocock)

(Unguipalpi, Bollman, Bul. 46, U. S. Nat. Mus. 1893, p. 164, Artiostigmata, Silvestri Lithobiomorpha, Pocock, Biologia Centrali-Americana, Part Chilopoda and Diplopoda, 1910)

The suborder Lithobiomorpha includes the forms of true centipedes most easily recognized. They are all very active and move very rapidly. The body has 15 pairs of ambulatory legs, the posterior pair being elongate and much heavier than the others. On the prosternal margin there are usually two or more pairs of teeth, which are called prosternal teeth (figure 13). The female gonopods are in the form of a pair of forceps, each of which ends in a claw, which may be one, two or three-lobed and bears at the base two or

three pairs of conspicuous spines. The third, fifth, eighth, tenth, twelfth and fourteenth body segments always possess a pair of spiracles. Some species may have a pair of spiracles on the first segment. The coxae of the last four (sometimes five) pairs of legs bear a number of glands which open through pores arranged either

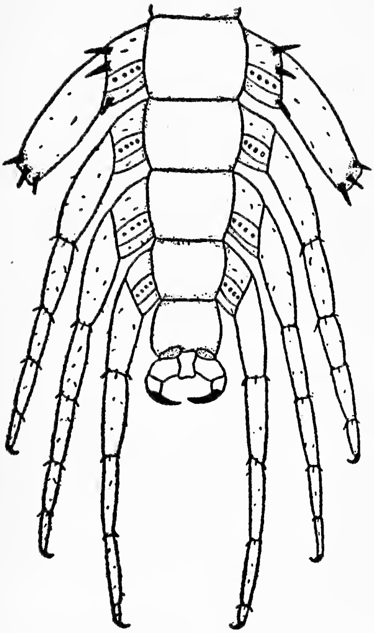

Figure 11 Showing the coxal pores of a centipede arranged in a single series.

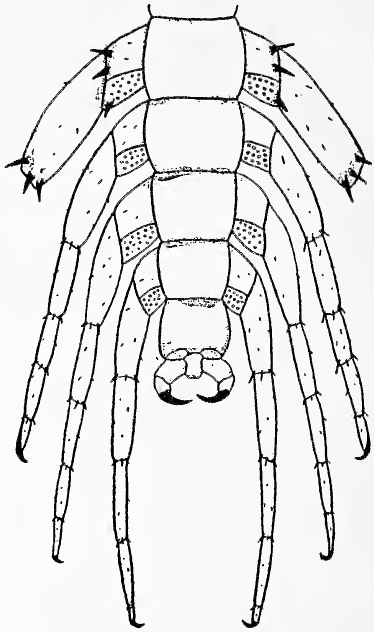

Figure 12 Showing the coxal pores of a centipede arranged in double series or group of coxal pores.

Figure 13 Showing prosternal teeth of a common centipede, *Lithobius*.

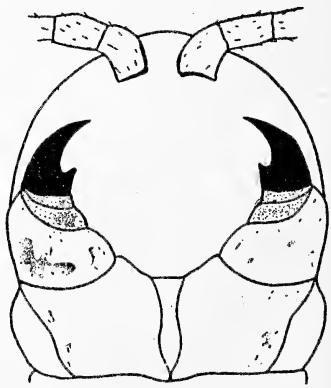

Figure 14 Ventral aspect of *Linleotaenia* species, showing conspicuously large tooth at the base of the prehensorial claw.

in a single regular series or in two or more irregular series (figures 11–12).

## Key to the New York Families of the Order Anamorpha (Suborder Lithobiomorpha)

*A* Legs bearing only bristles; no true spines being present.

*B* A single ocellus on each side of the head; anal segment in both young and adult with a pair of pores, the openings of the anal glands; claws of female gonopod entire
Family HENICOPIDAE Pocock

*BB* Eyes composed of several ocelli, anal pores not present in adults; claws of female gonopod tripartite (Not found in New York)
Family WATOBIIDAE Chamberlin

*AA* Legs bearing bristles and stout spines; ocelli either absent or in a group of several to many on each side

*B* Coxal pores in one series
Family LITHOBIIDAE Newport

*BB* Coxal pores in two or more series or scattered
Family ETHOPOLIDAE Chamberlin

### Family **Ethopolidae** Chamberlin

(Bulletin, Museum of Comparative Zoology, 1915, 59: 531, Cambridge, Mass.)

The American species of the family Ethopolidae have the posterior coxae armed with a stout spine, and the coxal pores are in two or more series. Three genera of the Ethopolidae are found in North America, two west of the Rocky mountains and one east. The genus found in New York is Bothropolys.

### Genus **Bothropolys** Wood

(Jour. Acad. Nat. Sci. Phila., n.s., 1865, 5:15. Trans. Amer. Phila. Soc., 1865, 13:152)

The genus includes only one species known to occur in New York State; *B multidentatus,* which was described by Newport in 1847.

### **Bothropolys multidentatus** (Newport)

(*Lithobius multidentatus,* Trans. Linn. Soc., 1845, 19:365, London; *Bothropolys nobilis,* Wood, Jour. Acad. Sci. Phila., n.s., 1863, 5:15; *Bothropolys multidentatus,* Wood, Trans. Amer. Phila. Soc. n.s., 1865, 13:152)

This species ranges in length from 15 to 27 mm. The head is much wider than long. Prosternal teeth 7 + 7 to 9 + 9. The coxal

pores are numerous and are arranged in three to five irregular series (figure 12). It is common in New York State and has been taken in nearly, if not all, of the states east of the Mississippi river.

**Known New York localities.** Wilmington, August 16, 1916, J. W. Bailey, coll.; Ithaca; Penn Yan; Albany; Thousand Islands; Upper Jay; Glen Haven; Rensselaer; Kenwood, Albany co.; Castleton; Staten Island; Forbes Manor, Rensselaer co.; Old Forge; East Onondaga; Hunter mountain, Wilmont; Crown Point; Caroline; Indian Head; Lake Placid; Raquette lake; North Creek; Karners; Fishkill; Saranac Lake; Big Moose; Cold Spring Harbor; Chautauqua lake and Linlithgo.

### Family **Lithobiidae** Newport

(Trans. of Linn. Soc. of London, 1845, 19:275)

The family Lithobiidae is represented in North America by 23 genera, six of which are known to occur in New York State. Members of this family have 15 pairs of legs. They are very active. The coxae of the last four pairs of legs bear a single series of pores (figure 11). When ocelli are present they form a group of several to many on each side. The legs bear both bristles and stout spines, the spines forming an important character in determining the species. In enumerating the spines, occurring on the ventral aspect of the first, next to the last and last pairs of legs " those found at the distal ends of the joints from the trochanter to tibia inclusive being listed in order; thus 1, 3, 3, 1 where the trochanter bears one, prefemur three, femur three, and tibia one." Also, " The number of prosternal teeth on the two halves of the prosternum is indicated by the appropriate figures separated by a dash; — e. g.; 3–3, where the number of teeth on each side is three."

### Key to the New York Genera of the Family Lithobiidae

*A* No ocelli present

*AA* Ocelli present

*B* Prosternal teeth 5 + 5 or more

*C* Posterior angles of ninth, eleventh and thirteenth dorsal plates produced (figure 15); antennae with 25 to 45 segments; prosternal teeth 5 + 5 to 10 + 10, or rarely but 4 + 4

Genus LITHOBIUS Leach

*CC* Posterior angles of none of the dorsal plates produced; articles of antennae more than 25

**Genus SOZIBIUS Chamberlin**

*BB* Prosternal teeth normally 2 + 2 or occasionally up to 4 + 4

*C* Fourth joint on anal leg of male with a lobe at proximal end bearing dense brush of very long hair

*CC* Fourth joint on anal leg of male not thus modified

*D* Articles of antennae 26 or more. (Posterior angles of the ninth, eleventh and thirteenth dorsal plates, or of seventh or sixth and seventh in addition produced)

*E* Line of apices of posternal teeth more or less procurved, the inner tooth of each being the larger; basal spines of gonopods of female slender

Genus PAITOBIUS Chamberlin

*DD* Articles of antennae normally 20, rarely as many as 24 (but when so none of the dorsal plates with posterior angles produced)

*E* Posterior angles of ninth, eleventh and thirteenth dorsal plates strongly produced; neither anal nor penult legs of male with any special pores or lobe; anal legs with two or more claws

Genus SONIBIUS Chamberlin

*EE* Posterior angles of none of dorsal plates produced or rarely those of the eleventh and thirteenth or of the ninth, eleventh and thirteenth weakly produced, but when so, claw of anal leg single; with few exceptions, either anal or penult legs in male with special lobe or ridges

*F* Fifth joint of anal legs of male always bearing on dorsal surface at distal end a conspicuous crest

Genus NADABIUS Chamberlin

*EEE* Posterior angles of the eleventh and thirteenth segments slightly produced or only the thirteenth feebly so; posterior coxa wholly unarmed; penult leg in male always bearing at distal end of tibia, on the dorsal side, a small conspicuous lobe; anal legs without lobes or crests

Genus NAMPABIUS Chamberlin

## Genus **Lithobius** Leach

(Trans. Linn. Soc. of London, 1815, 16:381)

North American species of the genus Lithobius have the ninth, eleventh and thirteenth dorsal plates produced. None of the coxae is armed ventrally. The third joint of all legs are armed with true dorsal spines. The antennae varies in length and possesses from 20 to 45 segments. The prosternal teeth range from 5 + 5 to 10 + 10, and in some rare cases but 4 + 4. Only one species of this genus is found in New York State.

### **Lithobius forficatus** Linnaeus

(*Scolopendra forficatus,* Linne, Syst. Nat. ed. 10, 1758, 1:638. *Lithobius forficatus,* Leach, Edinb. Encyc., 1815, 7:408)

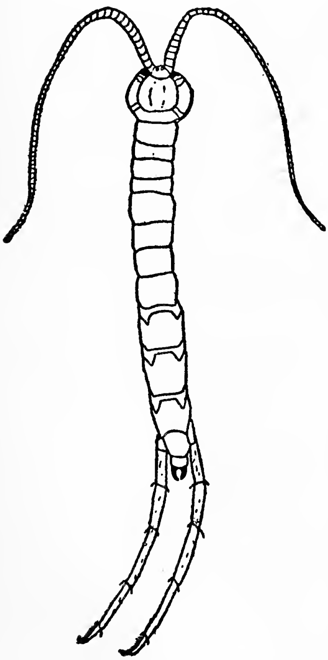

Figure 15 *Lithobius* species, showing the produced dorsal plates.

This species is the most common Chilopod found in New York State. It varies in color from brownish yellow to chestnut. None of the posterior coxae are laterally armed as in the other species of this group.

**Known New York localities.** Ithaca May 4, 1925; Saranac Lake, August 23, 1916, J. W. Bailey, coll.; also taken at Oyster Bay; Van Cortlandt Park, New York City; Cedar Hill; Plattsburg; Pine Hills, Albany; Altamont; Peobles island; Waterford; Gloversville; Albany; Queechy lake; Bay Shore, L. I.; Kenwood, Albany co.; Lake George; Rensselaer; Hunter mountain; Cold Spring Harbor; Glen Haven; Caroline; Old Forge; Raquette lake; Howe's Cave; Lewiston; Arrocher; Amityville; Crown Point; Silver Lake, S. I.; Upper Jay; Charlotte; Forbes Manor, Rensselaer co.; Fishkill; Rouses Point; Mount Marion; Syracuse; Niagara; Penn Yan; Hornell; Bronx Park; New York City.

## Genus **Nadabius** Chamberlin

(Bul. Mus. Comp. Zool., Cambridge, Mass., 1913, 57:62)

Members of the genus Nadabius have the fifth joint of the anal leg of the male always bearing on its dorsal surface at the distal end a conspicuous crest. Normally the articles of the antennae are 20 and never over 24. The prosternal teeth are 2 + 2 or in some cases as many as 4 + 4. Ocelli are always present. *N. aristeus* is the only species of this genus known to occur in New York.

### **Nadabius aristeus** Chamberlin

(Bul. Mus. Comp. Zool., Cambridge, Mass., 1922, 57:322)

This species is about one-half an inch long and has 20 to 21 segments in the antennae. The prosternal teeth are 4 + 4 (occasionally 3 + 3). The anal legs have two distinct claws. The last two pairs of coxae are laterally armed.

**Known New York localities.** Freeville, October 12, 1924, J. W. Bailey, coll.; also taken at Montour Falls; Ithaca; Baiting Hollow; and on the summit of Connecticut Hill in Tompkins county.

## Genus **Nampabius** Chamberlin

(Bul. Mus. Comp. Zool., Cambridge, Mass., 1913, 57:40)

Members of the genus Nampabius do not have the posterior coxa armed. The antennae consists of 20 segments; the posterior angles of the eleventh and thirteenth segments slightly produced. The penult legs of the male always bear a small but conspicuous lobe on the dorsal side of the distal end of the tibia. Two species of this genus are known to occur in New York State: *Nampabius fungiferopes* Chamberlin and *Nampabius lundii* Meinert. The latter species was collected in the early '80's near New York City by L. Lund and the types were deposited in the Museum at Copenhagen, Denmark. Meinert described *N. lundii* as *Lithobius lundii,* but his description is so meager that any attempt to separate his *N. lundii* from *N. fungiferopes,* Chamberlin, by means of a key would be fruitless.

### **Nampabius lundii** (Meinert)

(*Lithobius lundii* Meinert, Myriays, Mus. Hauniensis, 1866, 3:12. *Nampabius lundii,* Chamberlin, Bul. Mus. Comp. Zool., 1913, 62:60)

Meinert placed this species in the genus Lithobius, but in revising the genera of the family Lithobiidae in 1913, Chamberlin established the genus Nampabius and placed Meinert's *L. lundii* in it. The coxal

pores of *N. lundii* are 2, 3, 3, 2 while in its near relative *N. fungiferopes* they are 2, 2, 2, 2.

**Known New York localities.** New York City, 1883, L. Lund, coll.; Wilmont, August 1, 1903, F. C. Paulmier; coll.; Upper Jay; Forbes Manor, Rensselaer co., and Chautauqua lake.

### **Nampabius fungiferopes** (Chamberlin)

(*Lithobius fungiferopes*, Chamberlin, Proc. Acad. Nat. Sci. Phila., 1904, 56:652, *Nampabius fungiferopes*, Chamberlin, Bul. Mus. Comp. Zool., 1913, 62:43)

In this species neither the anal nor the penult legs possess any dorsal spines. The ventral spines of the anal leg are 0, 1, 1, 0, 0. The coxal pores are 2, 2, 2, 2.

**Known New York localities.** Ithaca, December 1903, R. V. Chamberlin, coll.; Hunter mountain, June 10, 1905, F. C. Paulmier, coll.; Montour Falls, October 8, 1924, C. R. Crosby, coll.; McLean Bogs Reservation, May 16, 1925, collected by members of the Cornell University entomology survey party. Very common throughout the State. (The Lloyd-Cornell Reservation.)

### Genus **Sonibius** Chamberlin

(Can. Ent., 1912, 44:176)

In this genus the posterior angles of the ninth, eleventh and thirteenth dorsal plates are strongly produced. The antennae are short and consist of twenty segments. The posterior legs of the male are without any special lobe or modifications. The last two or three pairs of coxae are laterally armed. Adults of this genus are scarcely one-half inch in length. Only two species of this genus are known to occur in New York, and they may be separated by the following key:

#### **Key to the New York Species of the Genus Sonibius**

*A* Anal legs bearing three distinct claws.

*B* Dorsal spines of twelfth legs, 1, 0, 3, 1, 1. Prosternal teeth 2 + 2.

PARVUS Chamberlin

*AA* Anal legs bearing only two distinct claws.

NUMIUS (Chamberlin)

### **Sonibius parvus** Chamberlin

(Bul. Mus. Comp. Zool., Cambridge, Mass., 1922, 57:315)

This species has been taken only once in New York State. The anal legs bear three distinct claws, and the dorsal spines of the

twelfth pair of legs are 1, 0, 3, 1, 1; the prosternal teeth are 2 + 2. Adult specimens are dusky brown, being lighter on the ventral plates, legs and the distal portion of the antennae. The coxal pores are small and arranged: 3, 4, 4, 3; 3, 4, 4, 3. Adults measure about 9 mm in length.

**Known New York localities.** Big Tupper lake, St Lawrence county, Thomas and F. K. Barbour, coll.

### Sonibius numius (Chamberlin)

(*Lithobius numius,* Chamb., Can. Ent., 1911, 43:102. *Sonibius numius* Chamb., Can. Ent., 1912, 44:177)

This species differs from *S. parvus* in that the anal legs have only two distinct claws; *S. parvus* has three. The penult legs have two accessory claws and the ventral spines are usually 0, 1, 3, 3, 2. The color is nearly uniform brown being somewhat lighter on the ventral side.

**Known New York localities.** Forbes Manor, Rensselaer co., May 25, 1905, F. C. Paulmier, coll.

### Genus Sozibius Chamberlin

(Ann. Ent. Soc. Amer., 1912, 5:152)

The genus Sozibius may be distinguished from its near relatives by the 5 + 5 prosternal teeth. The antennae has 25 to 35 segments. None of the dorsal plates is produced. The tarsi of all legs are divided. The last one or two pairs of coxae are laterally armed.

While three species compose this genus only one is found in New York State.

### Sozibius providens (Bollman)

(*Lithobius providens,* Bollman, Amer. Nat., 1887, 21:81; also in Proc. U. S. Nat. Mus., 1887, 10:258. *Sozibius providens,* Chamb., Bul. Mis. Comp. Zool., 1922, 57:268)

Adults of this species are about one-half inch long, light brown to yellowish in color. The antennae possess 28 to 35 segments. The dorsal spines of the second pair of legs are 0, 0, 3, 2, 1; while the ventral spines of the first pair of legs run 0, 0, 2, 3, 2; the female gonopods are strictly entire as contrasted to the bipartrite and tripartrite gonopods of the other two species of the genus Sonibius.

**Known New York localities.** Castleton; Staten Island, September 8, 1905, F. C. Paulmier, coll.

## Genus **Paitobius** Chamberlin

(Can. Ent., 1912, 44:175)

The genus Paitobius is represented in New York State by one species, *P. exiguns* (Meinert). Members of this genus have ocelli present. The prosternal teeth range from 2 + 2 to 4 + 4 but never above 4 + 4. The antennae has 26 + 34 segments, and the posterior angle of the ninth, eleventh and thirteenth dorsal plates are produced. In some variations the sixth or seventh or the sixth and seventh dorsal plates are also produced. The line of apices of the prosternal teeth is more or less procurved, the inner tooth of each being the larger. The basal spine of the gonopods of the female is slender. The tarsi of all of the legs are divided. The last one or two pairs of coxae are armed.

### **Paitobius exiguns** (Meinert)

(*Lithobius exiguns,* Meinert; Vidensk — Meddel, Naturalist, foren, Kjoben, 1884–86, p. 110. *Paitobius exiguns,* Chamberlin, Ann. Ent. Soc. Amer. 1911, 4:40, Can. Ent., 1911, 43:104)

This species was described by Meinert from specimens collected at New York City by L. Lund in 1883. No additional specimens have been taken.

**Known New York localities.** New York City, 1883, L. Lund, coll.

## Family **Henicopidae** Pocock

(Biol. Centr. Amer., Chilopoda and Diplopoda, 1910, p. 13)

In this family the legs bear only bristles, no true spines being present. A single ocellus is present on each side of the head. In both the young and the old there appears in the anal segment a pair of pores, the openings of the anal glands. So far as is known no males of this family have been found, indicating the possibility and probability of parthenogenetic reproduction. One species belonging to the genus Zygethobius has been collected in New York.

## Genus **Zygethobius** Chamberlin

(Ent. News, 1903, 4:335)

One species of this genus was collected at the Lloyd-Cornell Reservation, McLean, N. Y. The generic characters were well preserved in the specimen but the specific characters are not sufficient to place it in its proper specific group. The genus is characterized by having the tarsi of all legs two-jointed; and the absence of spiracles on the first segment.

**Known New York localities.** McLean Bogs Reservation, April 24, 1924, C. R. Crosby, coll.

## Order **Epimorpha** Haase

(*Schlesiens* Chilopoda, II. Chilop. Epimorpha, Inaugural Dissert, Breslau, 1880, p. 6)

Members of the order Epimorpha all have as many as 21 pairs of legs. The tergites of the body segments are rarely reduced or shortened. This order includes two suborders in which are found some of the most interesting species of the Chilopods. The two suborders may be distinguished by the use of the following key:

### Key to the suborders of the Order Epimorpha

*A* With 21 or 23 pairs of legs; pairs of spiracles may be 9, 10, 11 or 19

Suborder SCOLOPENDROMORPHA (Pocock)

*AA* With 31 or more pairs of legs; pairs of spiracles two less than the number of pairs of legs; the first and last body segments being without spiracles

Suborder GEOPHILOMORPHA (Pocock)

## Suborder **Scolopendromorpha** Pocock

(Biol. Centr. Amer., Chilopoda and Diplopoda, 1910, p. 13)

The members of this suborder all have 21 or 23 pairs of legs and the spiracles are either 9, 10, 11 or 19 pairs. Members of this group are for the most part inhabitants of the warmer regions of the earth and they include the larger centipedes of the topics and the arid southwestern portions of the United States. There are only three families of this suborder, only one of which is known to occur in New York.

### Key to the Families of Scolopendromorpha

(From Chamberlin, 1911, p. 471)

*A* Without eyes, tarsi of all legs excepting the anal and penult pairs unsegmented; tibia at distal and with one or two spines or with bristles arranged in longitudinal rows beneath.

Family CRYPTOPIDAE Leach

*AA* Eyes present, composed of four ocelli, on each side; tarsi of anterior legs all biarticulate; tibia without spines at distal end or rows of bristles beneath

*B* Spiracles angular, triangular or narrowly slitlike, parallel to long axis of body, tarsal spines absent or only one in number; cephalic plate often overlapping the first dorsal plate or in the other cases basal plate and longitudinal furrows present. (Not found in New York).
Family SCOLOPENDRIDAE Leach

*BB* Spiracles oval or circular, oblique to long axis of body; tarsal spines generally present and two in number on the anterior legs; cephalic plate never overlapping the first dorsal plate; basal plate and longitudinal furrows never present. (Not found in New York).
Family OSTOSTIGMIDAE Kraepelin

## Family **Cryptopidae** Leach

(Trans. Linn. Soc. of London, 1814, 11:384)

Three genera of the family Cryptopidae have been taken in New York State. They may be separated by means of the following key:

### Key to the Genera of the Family Cryptopidae

(From Chamberlin, 1911, p. 471–72)

*A* Twenty-one leg-bearing segments; pairs of spiracles nine or nineteen

*B* Last dorsal plate not longer than the penult, mostly shorter than wide, its caudal margin convexly excurved or bluntly angular.

*C* Pseudopleura not produced caudad into a slender process
Genus CRYPTOPS Leach

*CC* Pseudopleura produced caudad into a slender process. (Not found in New York)
Genus ANETHOPS Chamberlin

*BB* Last dorsal plate nearly twice as long as the penult, longer than wide, the caudal margin nearly straight

*C* Nine pairs of spiracles. (Not found in New York)
Genus THEATOPS Newport

*AA* Twenty-three leg-bearing segments; pairs of spiracles ten or eleven

*B* Anal leg with a claw and a two-jointed tarpus; prefemur of anal legs with but two spines; femur of prehensorial feet with a basal tooth

*C* Seventh segment without spiracles (ten pairs of spiracles present)

Genus OCTOCRYPTOPS Haase

*CC* Seventh segment with spiracles (eleven pairs of spiracles present). (Not found in New York)

Genus SCOLOPOCRYPTOPS Newport

*BB* Anal legs without claw and the tarsi transformed into a many-jointed antennae-like lash; prefemur of anal legs with rows of from three to six spines on ventral surface; femur of prehensorial feet without basal tooth. (Not found in New York)

Genus NEWPORTIA Gervais

## Genus **Cryptops** Leach

(Tran. Linn. Soc. London, 1814, 11:384)

This genus contains one New York species.

### **Cryptops hyalinus** Say

(Jour. Acad. Nat. Sci. of Phila., 1822, vol. 3)

This species is widespread throughout the eastern and southestern portion of the United States. Adults measure from 15 to 20 mm in length, and are reddish brown in color. The spiracles are small and circular. The prosternal margin is fitted with six or eight fine short hairs. This species is very slender. Eighteen sterna with cross furrow only, the nineteenth to twenty-first mostly unfurrowed. The inner margin of the pseudopleura rounded, the poriferous area having about 17 large pores, and the smooth caudal border being clothed only with scattered hairs. The prefemur of the anal legs with numerous spiniform bristles on the ventral side, but without any apical spiniform process. The femur is without any apical tooth or process, but is clothed ventrally with numerous spiniform bristles. On the ventral side of the tibia there are seven or eight comb-teeth.

**Known New York localties.** Rensselaer, September 21, 1905, F. C. Paulmier, coll.; Castleton; Staten Island; Cold Spring Harbor; Bronx Park, New York City.

## Genus **Otocryptops** Haase

(Schlesiens Chilopoda II, Chilop — Epimorpha, Zeitschr. f. Entomologie Neue Folge, 8 Heft, Breslau, Auch separat, 1881)

The members of this genus have 23 pairs of legs and 10 pairs of oval spiracles. The antennae consists of 17 segments. Adults range from 50 to 60 mm in length. One species is known to occur in New York.

### **Otocryptops sexspinosus** (Say)

(*Crytops sexspinosus* say, Jour. Phila. Acad. Sci., 1821, 2:102–14. *Scoloporyptops sexspinosus,* Gervais, Walckenaer, Hist. Natur. des Insects, Apt., 1847, 4:298)

This species is very common in New York. It is about two inches long, of a reddish brown color. The prosternal margin is nearly straight and smooth, without any indentation of the teeth. The ventral and inner spines of the prefemur of the anal legs are conspicuous. The dorsal and ventral plates are smooth, without any median furrow. The pseudopleural processes are large.

**Known New York localities.** Ithaca, May 31, 1916, J. W. Bailey, coll.; Cold Spring Harbor; Hunter mountain; Rensselaer; Thompson's lake, Albany co.; Fishkill; East Onondaga; Glen Haven; Castleton, Station Island; Syracuse; Arrocher; Bronx Park, New York City; Martinique; Caroline; Freeville.

## Suborder **Geophilomorpha** Pocock

(Biol. Centr. Amer., Chilopoda and Diplopoda, 1910, p. 35)

Members of this suborder have the body elongate and very slender, consisting of from 31 to 181 segments. *Gosiphilus bakeri* Chamberlin, a species collected in California has 181 pairs of legs (Chamberlin, 1912, p. 651–72). The number of segments varies, however, not only from family to family and genera to genera but also within the species, except in rare cases where the number is fairly constant. Eyes are always lacking. The antennae are short and the number of segments is always 14. The basal plate, the tergite to which the prehensorial feet belong, is always well developed; while a small plate, a remnant of a preceding tergite, may or may not show between it and the caudal margin of the cephalic plate. The mandibles may bear only pectinate lamella, which are made up of rows of slender comblike bristles borne upon a common base or plate; and in addition they may bear a strongly chitinized plate, dentate along its distal edge. This dental edge, while usually entire may be

subdivided. The first maxillae usually have their coxae fused together at the median line to form a single plate or coxosternum. Sometimes, however, they may be entirely separate. Each leg-bearing segment except the first and last bears a pair of spiracles.

This suborder contains ~~two~~ families known to occur in New York State. They may be separated by the following key: three

**Key to the Families of the Suborder Geophilomorpha**

*A* Mandible with a dentate lamellae and with one or more pectinate lamellae

*B* Antennae cylindrical, filiform, not broadest at base and attennuated distad; mandibles with a single pectinate lamella

Family SCHENDYLIDAE Cook & Collins

*BB* Antennae flattened, broadest at base and attennuated distad; mandible with several pectinate lamellae. (Not found in New York)

Family HIMANTARIIDAE Cook

*AA* Mandible without any dentate lamellae, with one or several pectinate lamellae

*B* Mandibles with two or more pectinate lamellae, coxa of first maxillae entirely separate from each other, pleurae of prehensorial segment exposed on each side of basal plate. (Not found in New York)

Families MECISTOCEPHALIDAE Verhoeff and ARRUPIDAE Chamberlin

*BB* Mandible with but a single pectinate lamella; coxae of first maxillae fused with each other at least proximally; pleurae of prehensorial feet not exposed on each side of basal plate

*C* Labrum entire, uniformly chitinized, coalesced with the cephalic plate excepting at ends; hypopharynx strongly developed; palpi of first maxillae thick, strongly arched together in a semicircle. (Not found in New York)

Family TAMPIYIDAE Chamberlin

*CC* Labrum free, tripartite, or with the divisions clearly traceable if secondarily coalesced; hypopharynx not usually developed; first maxillae not strongly arched in a semicircle

*D* Median piece of labrum extending along surface of the lateral with which it is fused at least in part, at the middle of the edge are borne two conspicuously larger and more strongly chitinized teeth; chitinous lines of prosternum well developed. (Not found in New York)

Family SONIPHILIDAE Chamberlin

*DD* Median piece of labrum entirely free, not bearing at the middle two teeth conspicuously larger and more strongly chitinized than those adjacent; chitinous lines absent or but weakly developed

*E* First maxilla with well developed lappets, middle piece of labrum small, the dentate margin caudad, lateral pieces pectinate dorsum bisulcate

Family GEOPHILIDAE Leach

*EE* First maxilla without lappets, middle pieces of labrum very large, overlapping the ends of the short lateral pieces, which are unarmed and dentate along its anterior edge; dorsum not bisulcate

Family LINOTENIIDAE Chamberlin

**Key to the New York Genera of the Family Geophilidae**

*A* Joints of prehensorial feet not dentate within; anal legs ending in claws

Genus GEOPHILUS Leach

*AA* Joints of prehensorial feet dentate within; anal legs not terminating in claws; the claws being replaced by a small seventh article

Genus ARENOPHILUS Chamberlin

*B* Last ventral plate narrow; pores of coxapleura not aggregated and opening into pits; anal legs with six joints beyond the coxapleura; with or without claws

*C* Ventral pores in four areas, two on anterior portion of plate and two on posterior portion; anal legs clawless. (Not found in New York)

Genus POLYCRICUS Humbert & Saussure

*CC* Ventral pores not in four areas as in *C* (above); anal legs with claws

Genus PACHYMERIUM Koch

## Genus **Geophilus** Leach

(Tran. Linn. Soc. London, 1814–15, vol. 11, pt 2, Sens. Str. Bergsoe oy Mein, 1766)

In the two New York species of this genus the prehensorial feet extend beyond the front margin of the head. The basal place is wide. The ventral pores are numerous.

### Key to the New York Species of the Genus Geophilus

*A* Frontal plate discrete

*B* Coxapleurae each with two pores

G. RUBENS Say

*BB* Coxapleurae each with five or six to many pores

G. MORDAX Meinert

*AA* Frontal plate not discrete

G. DEDUCENS Chamberlin

### **Geophilus deducens** Chamberlin

(Ann. Ent. Soc. of Amer., 1909, 3:180)

One specimen of this species was taken by Nathan Banks at Sea Cliff, Long Island. In general it resembled other species of the genus but may be easily separated from the other two New York species by an examination of the frontal plate. *G. deducens* has the frontal plate entire while in *G. rubens* and *G. mordax* it is discrete.

**Known New York localities.** Sea Cliff, L. I., Nathan Banks, coll., date unknown.

### **Geophilus rubens** Say

(Jour. Phila. Acad. Nat. Sci., 1821, 11:102–11)

*Geophilus rubens* (Say) is very common in the United States. The males have from 49 to 51 pairs of legs; while the females have 51 to 53 pairs. This species may be distinguished from *Geophilus deducens* (Chamberlin) and *G. mordax* by the key characters given above.

**Known New York localities.** Ithaca, May 3, 1916, and May 4, 1925, J. W. Bailey, coll.; Rensselaer; Bronx Park, New York City; Wilmont; Fishkill; Kenwood, Albany co.; Bay Shore, L. I.; Forbes Manor, Rensselaer co.; Altamont; Albany; Gloversville; Caroline.

### **Geophilus mordax** Meinert

(Proc. Amer. Phil. Soc., 1886, 23:218)

In common with *G. rubens* this species has the frontal plate discrete. It differs, however, from *G. rubens,* in that the coxapleurae have from five or six to many pores each. Specimen of *G. mordax* are distinctly red in color.

**Known New York localities.** Long Island, R. V. Chamberlin, coll.

### Genus **Arenophilus** Chamberlin

(Bul. Mus. Comp. Zool., 1912, 54:416)

In this genus the ventral plate is wide; anal pores are present and the anal legs are unarmed. The ventral pores are numerous but are condensed in very definite areas. The prehensorial feet are large and much exposed from above, extending well beyond the anterior margin of the head. One species of this genus is known in New York.

### **Arenophilus bipuncticeps** (Wood)

(*Geophilus bipuncticeps,* Wood, Jour. Acad. Nat. Sci. Phila., 1862, ser. 2, 5:45. *Arenophilus bipuncticeps,* Chamberlin, Bul. Mus. Comp. Zool., 1912, 54:416)

This species has been collected from only three New York localities, but it is very common in the Southern States. The chief characteristic that serves to distinguish it from its near relatives is the fact that the ventral pores are numerous and conspicuous and that they are arranged in a transverse area extending entirely across the ventral plate immediately in front of the caudal margin. The area appears as a very low triangle with the apex pointed caudad. Occasionally, says Chamberlin (1912b, p. 18), "this area is in the form of an elongate narrowly diamond shaped area."

**Known New York localities.** City Island, New York City, October 10, 1902; Oyster Bay, April 23, 1903 and Barlow, May 21, 1903, F. C. Paulmier, coll.

### Genus **Pachymerium** C. L. Koch

(System die Myriapoden, 1847, 3:85–187)

In this genus the prehensorial feet are always exposed from above, extending well beyond the anterior margin of the head. The joints of the prehensorial feet are distinctly denticulate within. The ventral plate is narrow; the anal legs have six joints beyond the coxapleura and are equipped with claws. Only one species is found in New York.

### Pachymerium ferrugineum (C. L. Koch)

(*Geophilus ferrugineum,* C. L. Koch, Deutsch Crust. Myr. Arach, 1835, v. 3. *Pachymerium ferrugineum,* Chamberlin, Bul. Mus. Comp. Zool., 1912, 54:415)

This species, although common throughout the Southwestern States, has been taken only once in New York. Its usual habitat is beneath stones and bricks but it is often found beneath the bark of trees and under fallen leaves. The number of legs ranges from 41 to 47 pairs. Adults measure from 15 to 35 mm in length.

**Known New York localities.** East Greenbush, June 9, 1902, F. C. Paulmier, coll.

### Family **Linoteniidae** (Chamberlin)

(Linoteniinae — Chamberlin, Bul. Mus. Comp. Zool., 1912, 54:409. Linoteniidae — Chamberlin, Pomona College Jour. Ent. and Zool.)

Members of this family, like the members of the family Geophilidae, have the halves of the coxosternum united at the middle, there being no pleuro sternal suture present; but may be differentiated from the Geophilidae by means of the following characters: The first maxillae are without lappets; the middle piece of the labrum is very large and is armed with a fringe of teeth or spines, and overlaps the end of the short lateral pieces, which are unarmed and dentate along their anterior edges. The ventral pores are in a well-marked transverse band in front of the caudal margin. The bands on the more caudal segments are usually divided at the median line. One genus is known in New York State.

### Genus **Linotenia** C. L. Koch

(System der Myriapod, 1847, 3:86)

Most species of this genus are bright red in color. The anal legs terminate in claws. Many small pores are present on the coxapleura; the antennae are filiform. The most important character, however, is the presence of a conspicuously large tooth at the base of each prehensorial claw (figure 14). The frontal suture is very distinct. Two species have been collected in New York. They may be recognized with the aid of the following key:

### Key to the New York Species of the Genus Linotenia

*A* Pairs of legs more than 60; 67–71 pairs in males, 71–81 pairs in females. (Not found in New York) BIDENS Wood

*AA* Pairs of legs less than 60

*B* Pairs of legs of male 47–55; of female 49–59 FULVA (Sager)

*BB* Pairs of legs 37–45

*C* Caudal margin of head angularly extended from sides to medial line, basal plate three times as wide as long CHIONOPHILA (Wood)

### **Linotenia fulva** (Sager)

(*Strigamia fulva,* Sager, Proc. Acad. Nat. Sci. Phila., 1856, 8:109. *Linotenia fulva* (Sager) Bollman, Bul. 46, U. S. Nat. Mus., 1893, p. 92, 98, 109, 184)

A very common species throughout the Southwestern and Northern States and easily determined with the aid of the preceding key.

**Known New York localities.** Ithaca, July 1, 1916, J. W. Bailey, coll.; Freeville; Hunter mountain; Montour Falls; Rensselaer; Kenwood, Albany co.; Bronx Park, New York City; Forbes Manor, Rensselaer co.; Silver Lake, S. I.; Van Cortlandt Park, New York City; Fishkill; East Orange; Syracuse; Cold Spring Harbor; Danby; McLean Bogs Reservation.

### **Linotenia chionophila** (Wood)

(*Strigamia chionophila,* Wood, Jour. Acad. Nat. Sci. Phila., 1862, ser. 2, 5:50. *Linotenia chionophila,* Chamberlin, Bul. Mus. Comp. Zool., 1912, 54:424)

This species is distinguished from *L. fulva,* (Sager) by the number of legs as indicated in the key. It is common in New York.

**Known New York localities.** Connecticut hill, Tompkins county, October 19, 1924, J. W. Bailey, coll.; Bronx Park, New York City; Glass lake, Rensselaer co.; Ithaca; Schenectady; Rouses Point; Raquette lake; Port Washington Park, New York City; Van Cortlandt Park, New York City; Kenwood, Albany co.; Arrocher; Saranac Lake; McLean Bogs Reservation.

### Family **Schendylidae** Cook & Collins

(Proc. U. S. Nat. Mus., 1895, 18:70)

In contrast to the family Geophilidae the family Schendylidae has mandibles with dentate lamellae. Two genera composed of three species are recorded from New York. The genera may be separated by the use of the key:

### **Key to the Genera of Schendylidae**

*A* Coxapleura of anal legs with numerous pores Genus ESCARYUS Cook & Collins

*AA* Coxapleura of anal legs each with only two pores
*B* Claws of anal legs rudimentary or wanting
*C* Claws of maxillary palpus simple, mandibles with a single dentate lamella; last joint of anal leg much reduced
Genus SCHENDYLA Bergsol & Meinert

### Genus **Escaryus** Cook & Collins

(Proc. U. S. Nat. Mus., 1891, 13:83)

This genus was originally described from New York but it is widely distributed over the eastern part of the United States and has also been recorded from Asia (Cook, '99). Ventral pores which were present in Schendyla are wanting in this genus. Two species have been taken from New York.

**Key to the New York Species of the Genus Escaryus**

*A* Females with 41–51 pairs of legs
*B* Length 30 mm upwards
*BB* Length less than 30 mm
*C* Last segment with 17 pairs of pleural pores; pairs of legs in female 49
LIBER Cook & Collins
*CC* Last segment with 25 pairs of pleural pores; pairs of legs in female 41
URBICUS (Meinert)

### **Escaryus liber** Cook & Collins

(Proc. U. S. Nat. Mus., 1891, 13:394)

This species was described from one female found among leaves and rotten wood at Kirkville, Onondaga county, N. Y., April 1890. It differs from *E. urbicus* (Meinert) in that the female has 49 pairs of legs instead of 41 pairs as in *E. urbicus* (Meinert). The body is also slightly more slender than that of *E. urbicus* (Meinert). The labrum is entirely free, the anterior and posterior margin being merely straight and subparallel except at the base. The prehensorial feet do not attain the frontal margin of the head. The pleurae pores of the last segment number 17 pairs.

**Known New York localities.** Kirkville, Onondaga county, April 1890, O. F. Cook and G. N. Collins, coll.

### Escaryus urbicus (Meinert)

(*Geophilus urbicus,* Meinert, Proc. Amer. Phil. Soc., 1885, 21:218. *Escaryus phyllophilus,* Cook & Collins, Proc. U. S. Nat. Mus., 1891, 13:392 *Escaryus urbicus,* Cook, Harriman, Alaska Exp., Insects, Part I, 1910, p. 76)

This species has 25 pairs of pleural pores on the last segment and the female has 41 pairs of legs. The labrum is joined at its lateral edges to the frontal lamiura, the anterior and posterior edges being convexed outwardly on each side of the middle. The prehensorial feet do not attain the frontal margin of the head. Described from two females found among fallen leaves near Oakwood Cemetery, Syracuse, N. Y., but now very common in the State.

**Known New York localites.** Syracuse, January 1890, O. F. Cook and G. N. Collins, coll.; Ithaca, December 1903 and January, February and March 1904. Very numerous, R. V. Chamberlin, coll.

### Genus **Schendyla** Bergsoe and Meinert

(Naturk. Tidsskr., 1866, 14:103)

In this genus the ventral pores are small and are situated in the middle anterior sterna. Anal pores are wanting. Mandibles have one dentate and one pectinate lamella. The claws of the maxillary palpus is simple. Only one species of this genus is known to occur in New York.

### Schendyla nemorensis (C. Koch)

(*Geophilus nemorensis,* C. Koch, Deutschl, crust, etc. Hft. 9, Tat. 4, 1837, p. 168)

In this species the body is slender and yellowish or wax colored. The head is light brown, sparsely pilose with short rigid hairs. The prehensorial feet scarcely attain the frontal margin of the head. Adults measure about 25 mm in length. They possess 41 pairs of legs. Anal pores are wanting.

**Known New York localities.** Clyde, December 1889, L. M. Underwood, coll.; Staten Island; Hunter mountain; Kenwood, Albany co.; Baiting Hollow; Ithaca.

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# New York State Museum Bulletin

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NEW YORK STATE MUSEUM

CHARLES C. ADAMS, *Director*

# THE MINING AND QUARRY INDUSTRIES OF NEW YORK FOR 1925 AND 1926

BY


D. H. NEWLAND, *State Geologist*

AND

C. A. HARTNAGEL, *Assistant State Geologist*




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# New York State Museum Bulletin

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## THE MINING AND QUARRY INDUSTRIES OF NEW YORK FOR 1925 AND 1926

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### INTRODUCTION

New records were set by the reports from the mining and quarry industries of the State in 1925 and 1926. Most branches, and especially those connected with the building trades, were stimulated by an exceptionally active demand, and the shipments in both years greatly exceeded those in any previous similar period. The returns for 1925 showed mineral production reached an aggregate value of $103,213,093, and for 1926 a value of $113,249,609, an advance of nearly 18 per cent in the two years. The gains, although notable in themselves, marked only a continuation of the upward trend of the industries that has been in progress for several years, practically since the close of the war, in which time the industries have about doubled their shipments.

More than 30 different items are included in the list of products on which the above figures are based. They are mainly materials in their first marketable forms as shipped by mining and quarry companies. They do not include metallurgical and chemical manufactures like iron and steel, special alloys of iron, aluminum, carborundum, alkali products and many other materials of secondary nature whose combined value greatly exceeds that of the basic products under consideration.

As a mineral producing state New York ranks in the first division on the basis of its contributions, being 14th or 15th on the list. According to the statistics (1925) available for all of the states, New York stands first in quantity and value of production of six minerals. These are gypsum, followed by Iowa, Ohio and Michigan;

garnet, with New Hampshire the only other producing state; emery, New York being the only state where emery is mined; millstones, with Virginia, New Hampshire and North Carolina following in the order named. In ground talc New York ranks first in production and value. In volume of production New York has first place in the output of sand and gravel, but in value is exceeded by Pennsylvania. In production and value of salt New York ranks second, being preceded by Michigan and followed by Ohio and Kansas. New York holds third place in production and value of slate, being preceded by Pennsylvania and Vermont and followed by Maine. In production of pyrite New York ranks third, the two leading states being California and Virginia. In production of feldspar New York holds fourth place, preceded by North Carolina, New Hampshire and Maine. The value of stone produced in the State is exceeded by that of Pennsylvania, Ohio and Michigan. In volume of production California surpassed New York, but the value was less.

## Cement

Shipments of portland cement in 1926 amounted to 8,535,862 barrels, valued at $14,864,066. The large annual increase in the production of portland cement noted in recent years was not apparent in 1926, when the shipments exceeded those of 1925 by only 1773 barrels. Nine portland cement plants were in operation in 1926. Two of these are located in Columbia county, three in Greene county and one each in Schoharie, Onondaga, Tompkins and Warren counties. Two new portland cement plants in Erie county will start production in 1927. These, no doubt, will add materially to the annual production of portland cement in this State. Natural cement is manufactured in Ulster and Erie counties. Annual production of natural cement is but a few thousand barrels, although at one time it far exceeded that of portland cement.

## Clay Products

In 1926 the number of building brick produced amounted to 1,323,011,000, valued at $17,603,879. This is the largest production in recent years and in value exceeds the 1925 output of 1,072,127,000 brick by over $4,000,000. More than 80 per cent of the total output of common brick is produced in counties bordering the Hudson river, where shipments are made by barge to the metropolitan districts. Production of clay wares, such as terra cotta, tile and sewer pipe, in 1926 amounted to $4,072,983, as compared with $4,269,910 for the year 1925, a slight loss. Pottery accounted for

a total of $7,505,037, a gain over 1925, when the value was $7,375,907.

### Garnet

Shipments of Adirondack garnet from the mines in Warren and Essex counties amounted to 5812 tons, valued at $494,050. This is considerably less than in 1925, when 7614 tons, having a value of $669,545 were shipped.

### Gypsum

The mining of gypsum has become one of the State's most important mineral industries and has shown a regular increase in production during recent years. The number of tons of gypsum mined in 1926 was 1,723,460, with a sales value for the crude and processed materials of $16,794,589. The corresponding figures for 1925 were 1,730,254 tons, value $16,219,906. All the active gypsum mines are located in western New York. Recent discoveries of additional gypsum deposits in Erie county have added considerably to the gypsum reserves of the State. Plans for opening a new gypsum mine east of those at present producing are under way at Victor, Ontario county.

### Iron Ore

In 1926 shipments of iron ore including the portion used for metallic paint amounted to 673,103 long tons valued at $3,103,312. In 1925 shipments were 429,248 long tons valued at $2,074,426. The increase in shipments in 1926 represents in part accumulated stocks rather than a normal increase in production.

### Mineral Waters

The estimated production of mineral waters in 1926 amounted to 7,063,520 gallons valued at $844,154.

### Natural Gas

Production of natural gas in New York in 1926 was 7,027,000 M cubic feet valued at $4,499,000. In 1925 the production amounted to 6,210,000 M cubic feet. The increase in production noted in 1926 over the previous year is not anticipated to remain constant, for present supplies are being rapidly depleted and only by extensive drilling can present production be maintained.

### Petroleum

The oil fields of southwestern New York in 1926 produced 1,956,000 barrels of petroleum valued at $7,300,000. This is the largest production in over 35 years. The annual increase in oil

production during recent years is due to the use of new and improved methods for extracting additional amounts of oil from the sands in the old oil pools.

### Salt

The total amount of salt produced in 1926 amounted to 14,297,000 barrels valued at $6,564,829. In 1925 there were produced 14,671,214 barrels valued at $7,133,244. This represents a decrease in production from the year 1925 of 374,214 barrels.

### Sand and Gravel

Sand and gravel, other than molding sand, produced in 1926 amounted to 18,662,612 tons valued at $10,413,831. This was a substantial increase over the 1925 production of 14,295,006 tons valued at $8,603,361. Molding sand, the production of which is centered about Albany county, amounted in 1926 to 671,748 tons valued at $1,171,821. The production shows but little change from the preceding year.

### Slate

The slate belt of Washington county yielded slate having a value of $913,814 in 1926. In 1925 the value was $851,715. Most of the value is represented by crushed slate.

### Stone

In 1926 the value of the quarry products, including granite, marble, sandstone, trap, lime and limestone, but exclusive of limestone used in cement making, amounted to $14,730,267, as compared with $13,626,032 in 1925. The value of limestone alone exceeded $11,000,000 for each year.

### Talc

In 1926 production of talc amounted to 83,231 tons valued at $1,030,075. The 1925 output was 85,109 tons valued at $993,913.

### Zinc Ore

Zinc ore is mined in St Lawrence county, where operations have been carried on since 1915. Ore produced in 1926 amounted to 42,500 tons valued at $756,150. In 1925 the output was 47,254 tons valued at $784,016.

### Other Materials

Among the miscellaneous minerals produced in the State during 1926 are the following: Crude or raw clay, 13,688 tons, value $98,616; diatomaceous earth, 187 tons, value $12,770; emery, 386 tons, value $3,641; feldspar and quartz, 19,514 short tons, value $170,986; millstones valued at $23,629; gasoline, recovered from

natural gas, 539,000 gallons, value $66,000; pyrite, 7635 long tons, value $17,179; sand-lime brick, 11,510,000, value $158,283.

The statistics and statistical tables contained in this publication are compiled from the individual reports of more than 1200 mineral producers in the State, to whom acknowledgment is given for their cooperation and interest. The work of collecting statistics is carried on by this office in cooperation with the United States Bureau of Mines and the Bureau of the Census, the latter confining its activities to the clay products and the sand-lime brick industries.

**Mineral production in New York in 1925**

| PRODUCT | UNIT OF MEASUREMENT | QUANTITY | VALUE |
|---|---|---|---|
| Portland cement | Barrels | 8 534 089 | $14 967 642 |
| Natural cement | Barrels | .......... | *a* |
| Building brick | Thousands | 1 072 127 | 13 165 999 |
| Pottery | .......... | .......... | 7 375 907 |
| Other clay products | .......... | .......... | 4 269 910 |
| Carbon dioxide | Pounds | .......... | *a* |
| Crude clay | Short tons | 7 503 | 47 637 |
| Diatomaceous earth | Short tons | 114 | 7 528 |
| Emery | Short tons | 769 | 5 907 |
| Feldspar and quartz | Short tons | 13 600 | 77 922 |
| Garnet | Short tons | 7 614 | 669 545 |
| Gypsum | Short tons | 1 730 254 | 16 219 906 |
| Iron ore | Long tons | 413 517 | 1 988 735 |
| Millstones | .......... | .......... | 14 063 |
| Metallic paint | Short tons | 17 619 | 85 691 |
| Mineral waters [b] | Gallons | 7 058 351 | 843 637 |
| Natural gas | 1000 cubic feet | 6 210 000 | 3 778 000 |
| Natural-gas gasoline | Gallons | 414 000 | 46 000 |
| Peat | Short tons | 767 | 7 797 |
| Petroleum | Barrels | 1 695 000 | 6 270 000 |
| Pyrite | Long tons | 12 000 | 27 000 |
| Salt | Barrels | 14 671 214 | 7 133 244 |
| Molding sand | Short tons | 671 610 | 1 147 072 |
| Other sand and gravel | Short tons | 14 295 006 | 8 603 361 |
| Sand-lime brick | Thousands | 13 259 | 190 870 |
| Slate | .......... | .......... | 851 715 |
| Granite | Short tons | 96 850 | 349 443 |
| Limestone [c] | Short tons | 8 488 910 | 10 149 440 |
| Lime | Short tons | 104 829 | 1 030 960 |
| Marble | Short tons | 72 270 | 510 900 |
| Sandstone | Short tons | 211 170 | 1 348 455 |
| Trap [d] | Short tons | 160 750 | 236 834 |
| Talc | Short tons | 85 109 | 993 913 |
| Zinc ore | Short tons | 47 254 | 784 016 |
| Other materials | .......... | .......... | 14 044 |
| Total value | .......... | .......... | $103 213 093 |

*a* Included under other materials.
*b* Quantity and value partly estimated.
*c* Exclusive of limestone used for cement making.
*d* Includes value of miscellaneous stone.

Mineral production in New York in 1926

| PRODUCT | UNIT OF MEASUREMENT | QUANTITY | VALUE |
|---|---|---|---|
| Portland cement | Barrels | 8 535 862 | $14 864 066 |
| Natural cement | Barrels | .......... | *a* |
| Building brick | Thousands | 1 323 011 | 17 603 879 |
| Pottery | .......... | .......... | 7 505 037 |
| Other clay products | .......... | .......... | 4 072 983 |
| Carbon dioxide | Pounds | .......... | *a* |
| Crude clay | Short tons | 13 688 | 98 616 |
| Diatomaceous earth | Short tons | 187 | 12 770 |
| Emery | Short tons | 386 | 3 641 |
| Feldspar and quartz | Short tons | 19 514 | 170 986 |
| Garnet | Short tons | 5 812 | 494 050 |
| Gypsum | Short tons | 1 723 460 | 16 794 589 |
| Iron ore | Long tons | 673 103 | 3 103 312 |
| Millstones | .......... | .......... | 23 629 |
| Metallic paint | .......... | .......... | *b* |
| Mineral waters [e] | Gallons | 7 063 520 | 844 154 |
| Natural gas | 1000 cubic feet | 7 027 000 | 4 499 000 |
| Natural-gas gasoline | Gallons | 539 000 | 66 000 |
| Peat | Short tons | .......... | *a* |
| Petroleum | Barrels | 1,956 000 | 7 300 000 |
| Pyrite | Long tons | 7 635 | 17 179 |
| Salt | Barrels | 14 297 000 | 6 564 829 |
| Molding sand | Short tons | 671 748 | 1 171 821 |
| Other sand and gravel | Short tons | 18 662 612 | 10 413 831 |
| Sand-lime brick | Thousands | 11 510 | 158 283 |
| Slate | .......... | .......... | 913 814 |
| Granite | Short tons | 103 200 | 646 200 |
| Limestone [d] | Short tons | 9 163 560 | 10 955 863 |
| Lime | Short tons | 107 326 | 1 016 647 |
| Marble | Short tons | 80 730 | 673 322 |
| Sandstone | Short tons | 144 700 | 1 171 885 |
| Trap [c] | Short tons | 216 510 | 266 350 |
| Talc | Short tons | 83 231 | 1 030 075 |
| Zinc ore | Short tons | 42 500 | 756 150 |
| Other materials | .......... | .......... | 36 648 |
| Total value | .......... | .......... | $113 249 609 |

*a* Included under other materials.
*b* Included under iron ore.
*c* Includes value of miscellaneous stone.
*d* Exclusive of limestone used for cement making.
*e* Quantity and value partly estimated.

**Distribution of mineral production by counties in 1925**

| COUNTY | MINERALS PRODUCED | VALUE |
|---|---|---|
| Albany | Slip clay, limestone, molding sand, sand and gravel, clay products | $2 297 981 |
| Allegany | Natural gas, natural-gas gasoline, sand and gravel, petroleum | *a* 1 042 223 |
| Broome | Sandstone, clay products, sand and gravel | 391 709 |
| Cattaraugus | Natural gas, natural-gas gasoline, clay products, sand and gravel, molding sand, petroleum | *a* 1 291 394 |
| Cayuga | Limestone, mineral waters, iron ore, sand and gravel, molding sand | 265 908 |
| Chautauqua | Mineral waters, natural gas, clay products, molding sand, petroleum | *a* 2 185 020 |
| Chemung | Clay products, mineral waters | 191 554 |
| Chenango | Sandstone | 104 412 |
| Clinton | Granite, lime, marble, iron ore, limestone, sand and gravel | 871 779 |
| Columbia | Portland cement, mineral waters, clay products, molding sand | 7 456 934 |
| Cortland | Mineral waters | *b* |
| Delaware | Sandstone, sand and gravel | 168 544 |
| Dutchess | Marble, lime, limestone, mineral waters, peat, clay products, sand and gravel, molding sand | 2 484 507 |
| Erie | Crude clay, lime, limestone, gypsum, mineral waters, natural gas, clay products, sand-lime brick, sand and gravel | 6 866 404 |
| Essex | Iron ore, granite, mineral waters | 1 384 067 |
| Franklin | Sandstone, sand and gravel | *b* |
| Fulton | Feldspar, limestone, granite, lime | 136 693 |
| Genesee | Limestone, salt, sand and gravel, gypsum, mineral waters, natural gas, clay products | 14 029 553 |
| Greene | Portland cement, limestone, molding sand, mineral waters, clay products | 4 711 422 |
| Herkimer | Limestone, diatomaceous earth, granite | 184 320 |
| Jefferson | Limestone, lime, granite, sand and gravel, mineral waters | 351 282 |
| Kings | Crude clay, sand and gravel, molding sand, clay products | 599 415 |
| Lewis | Talc, limestone | *b* |
| Livingston | Salt, natural gas, sand and gravel | 3 827 276 |
| Madison | Limestone, sand and gravel | 264 274 |
| Monroe | Limestone, mineral waters, clay products, gypsum, natural gas, sand-lime brick, sand and gravel, molding sand | 2 976 951 |
| Montgomery | Limestone, mineral waters, clay products | 336 629 |
| Nassau | Clay products, sand and gravel, molding sand | 2 870 121 |
| New York | Clay products | *b* |
| Niagara | Clay products, limestone, sandstone | 479 629 |
| Oneida | Limestone, mineral waters, iron ore, clay products, sand and gravel, molding sand | 604 660 |
| Onondaga | Limestone, salt, crude clay, portland cement, natural gas, clay products, sand and gravel, sand-lime brick | 5 993 386 |
| Ontario | Limestone, natural gas, clay products, sand and gravel | 1 683 504 |
| Orange | Limestone, iron ore, clay products, sand and gravel, molding sand | 1 073 505 |

| COUNTY | MINERALS PRODUCED | VALUE |
|---|---|---|
| Orleans | Sandstone, sand and gravel | 360 085 |
| Oswego | Mineral waters, natural gas, glass sand, sand and gravel | 542 730 |
| Otsego | Sandstone | *b* |
| Queens | Crude clay, clay products, sand and gravel, molding sand | 84 359 |
| Rensselaer | Mineral waters, clay products, sand and gravel, molding sand | 865 935 |
| Richmond | Clay products | 1 168 620 |
| Rockland | Limestone, basalt, mineral waters, clay products. | 2 447 221 |
| St Lawrence | Limestone, talc, pyrites, marble, feldspar, mineral waters, zinc ore, sand and gravel, molding sand. | 1 914 258 |
| Saratoga | Feldspar, limestone, mineral waters, clay products, carbon dioxide, sand and gravel, molding sand | 1 663 248 |
| Schenectady | Clay products, sandstone, sand and gravel, molding sand | 1 187 283 |
| Schoharie | Limestone, sandstone, portland cement, mineral waters | 1 428 034 |
| Schuyler | Salt, natural gas, sand and gravel | 1 412 901 |
| Seneca | Lime | *b* |
| Steuben | Natural gas, clay products, sandstone, sand and gravel, petroleum | *a* 264 006 |
| Suffolk | Clay products, peat, sand and gravel | 2 082 958 |
| Sullivan | Miscellaneous stone | *b* |
| Tioga | Sand and gravel, molding sand | *b* |
| Tompkins | Portland cement, salt, sandstone, sand and gravel. | 2 115 517 |
| Ulster | Limestone, lime, sandstone, millstones, natural cement, clay products, sand and gravel, molding sand | 5 512 928 |
| Warren | Portland cement, lime, limestone, garnet | 2 774 291 |
| Washington | Limestone, lime, slate, sand and gravel | 928 698 |
| Wayne | Iron ore, sand and gravel, molding sand | 12 555 |
| Westchester | Limestone, quartz, feldspar, granite, emery, marble, mineral waters, clay products, sand and gravel | 1 634 478 |
| Wyoming | Salt, sandstone, natural gas, sand and gravel | 1 185 769 |
| Yates | Natural gas | *b* |
| Other counties. | | 232 163 |
| Total | | $103 213 093 |

*a* Exclusive of the value of petroleum which could not be divided according to counties. Most of the production is from Allegany and Cattaraugus counties. A small amount is produced in Steuben county and a few wells are now producing in Chautauqua county. The state production valued at $6,270,000 is included in the state total.

*b* Included under other counties.

## APATITE

This mineral is a crystallized form of calcium phosphate and when pure contains about 90 per cent tri-calcium phosphate and 10 per cent of calcium fluoride, which may be replaced by calcium chloride. It is the common carrier of phosphorus in the crystalline rocks—granites, gneisses and metamorphosed limestones—in which it is usually found in small proportions, rarely more than 1 per cent or so. It is also present in iron ores, occasionally in considerable amounts so that they are unsuitable for metallurgical use unless first treated for the removal of the apatite. It is in this process of milling and separating apatite from some of the magnetite ores that commercial phosphate materials have been mainly produced in this State.

The amorphous rock phosphates which occur in surface concentrations and in sedimentary beds, commonly associated with marine nonmetamorphosed limestones, have no representation in New York. They yield the bulk of the market supplies for fertilizing purposes, having a wide development in some of the southern states and in the West.

Apatite constitutes a by-product in the preparation of the magnetite ores in the Mineville district, Essex county. The "old bed" group of deposits there contain as much as 8 or 10 per cent of the mineral in granular intermixture with the magnetite. Although the ore is sufficiently high in iron to be shipped directly in lump form, its treatment is desirable for most furnace uses. The method employed consists first in crushing the material sufficiently fine to release the apatite from mechanical combination with the magnetite. The crushed product graded into sizes is then carried on belts into the fields of strong magnets which pick up or divert the iron mineral from the stream of the nonmetallic ingredients and thus give a nearly clean magnetite concentrate. The tailings carry apatite, with a small proportion of iron and considerable amounts of quartz, hornblende and feldspar, which are the common constituents of the country rocks. Large quantities of the apatite-bearing tailings have been made from these milling operations on old bed ores. To put them into commercial form they have to be subjected to further treatment to remove the iron and silicates. They are reground and reconcentrated on magnetic machines, gravity tables and jigs until the phosphorus content is raised to at least 8 or 9 per cent, corresponding to 40 to 45 per cent of bone phosphate. The product is then finely ground.

There are no other magnetite deposits in the State, so far as known, that contain enough apatite to warrant similar operations for its recovery and utilization.

The occurrence of apatite in the crystalline limestone formations may be noted, more on account of their mineralogical interest than of possible commercial importance. Among the localities which afford good crystallized specimens are Gouverneur and Hammond, St Lawrence county; Natural Bridge, Lewis county; and Amity, Orange county. The contact zones between granite and limestone are frequently characterized by the occurrence of apatite.

A phosphate mineral called eupyrchroite, an amorphous calcium phosphate closely resembling apatite, has been produced on a small scale in years past. The single known locality for the mineral is just south of Crown Point, Essex county, near the shore of Lake Champlain. It is mentioned in the reports of the First Geological Survey, and mining operations were carried on for a time about the year 1850. The usual form of the substance is a massive aggregate, sometimes showing a concretionary or botyroidal structure, of bluish to grayish colors. An analysis by Charles T. Jackson, published in the American Journal of Science (series 2, v. 12, 1851, p. 73) showed 92.94 per cent of tri-calcium phosphate.

## ARSENICAL ORE

Small shipments of arsenical minerals have been made at different times from local deposits, although none was reported in 1925 or 1926. The minerals known to occur in New York include arsenopyrite, which is a sulpharsenide of iron with a theoretical content of 46 per cent arsenic, leucopyrite, sesquiarsenide of iron with 64.1 per cent arsenic, and scorodite, a hydrous iron arsenate with 32.4 per cent arsenic. The commonest of the compounds is arsenopyrite, which is the principal ore for the production of commercial arsenic. It occurs in Orange, Putnam and Essex counties in veins intersecting the Precambrian crystalline rocks.

A deposit near Pine pond, town of Kent, Putnam county, has been the chief source of the small output of ore hitherto recorded for the State. This occurrence is known to have been explored as early as 1847, and in 1888 a small quantity of the ore was shipped to New Jersey. In 1906 the Putnam County Mining Corporation undertook the development of the property. At first the ore was sorted and the richer material shipped in lump form to chemical plants abroad, so it was stated. In the following year a small mill was built to treat the lower grade ore, from which concentrates

carrying about 25 per cent arsenic were recovered. The mill was equipped with a jaw crusher and rolls for reduction of the lump to a size required to release the arsenopyrite from the gangue and with small hand-operated jigs of the Joplin type for separating the minerals. The jig capacity was 4½ tons of crude ore, from which 1½ tons of concentrates were recovered. The operations were continued for a year or two, when a decline in the market for arsenical products caused a shutdown. They have not since been revived, although some effort in that direction was made during the war period.

So far as the conditions are revealed by exploration, they indicate that the occurrence is a fissure vein which cuts through the gneiss in a north-south direction at a high angle. Parallel to and on one side of the vein is a dike of intrusive rock, the outcrop of which can be followed as a distinct ridge for half a mile along the strike. The dike is from 100 to 300 yards wide. It is probably an original peridotite, as the analysis of a sample shows a low silica content (35.5 per cent) with a high percentage of magnesia (37.64 per cent) which would correspond to a rock of that type.

The vein-filling consists of white quartz carrying a variable proportion of arsenopyrite and pyrite. Samples may be found that are mixtures practically of the two metallic minerals, but in general quartz is the predominant constituent. Pyrite is less abundant than arsenopyrite, its proportions averaging perhaps from three-fifths to one-half of the arsenical mineral. The content of metallic arsenic ranges up to the theoretical amount required by the chemical formula. With hand sorting a fairly large proportion will average 25 per cent which is considered marketable grade. A mixed sample of the high and low grade ores was analyzed by H. F. Gardner, formerly of the Museum staff, with the following results:

| | |
|---|---|
| $SiO_2$ | 26.84 |
| $Al_2O_3$ | .26 |
| CaO | .01 |
| MgO | Nil |
| $P_2O_5$ | .05 |
| S | 25.07 |
| Fe | 28.83 |
| As | 18.51 |
| Cu | .16 |
| Mn | tr |
| Co | Nil |
| Ni | Nil |
| | 99.73 |

The figures indicate a mineral composition of 40.20 per cent arsenopyrite, 32.31 per cent pyrite and .39 per cent chalcopyrite which is the source of the copper content.

Edenville, Orange county, is a locality for arsenical minerals, including arsenopyrite, leucopyrite, and scorodite. The first named is found in crystalline limestone in association with gypsum and orpiment. Leucopyrite is distributed in small amounts in a dioritic rock. Considerable prospecting was done at one time on the Brown farm between Edenville and Mount Adam. An occurrence of arsenopyrite is listed in Beck's Mineralogy of New York (1842, p. 394) at a locality in the town of Lewis, Essex county, 10 miles south of Keeseville.

## CARBON DIOXIDE

Carbon dioxide is classed as a mineral when it occurs free, naturally stored within the earth. Mostly it is produced artificially by combustion of coal or coke, by fermentation in brewing and by calcination of mineral carbonates like limestone, dolomite and magnesite. Its principal use is in the carbonating of beverages.

Natural carbon dioxide exists in the mineral waters of Saratoga and Ballston springs, being held in solution by the waters as they occur in the underground reservoirs and separating from them as they issue at the surface with diminishing pressure. For many years its collection and distribution was an industry of importance in Saratoga and vicinity, the value of the output exceeding that reported for the sales of mineral waters by themselves. The industry was finally discontinued with the erection of the State reservation and the cessation of pumping under legal restraint. Since then only surplus gas has been sold separately, although the natural supplies are used locally in the charging of the bottled mineral waters for general consumption.

The presence of large quantities of free carbon dioxide in the waters is the most interesting and intrinsically important feature of the Saratoga-Ballston district. There is no other spring resort in the State or in the whole eastern part of the country that is comparable in that respect. Similar examples of highly carbonated waters are found on the Pacific Coast and at some of the celebrated European spas. The source of the gas is an unsolved problem, further than that it must come from great depths before it joins the body of artesian waters which have their head at some distance from the Saratoga fault where they are collected. Professor Kemp (Mus. Bul. 159, 1912), who has made a special study of the springs, is

inclined to the opinion that the gas is essentially an igneous emanation, produced through the cooling of a magma at depth. The gas might be occluded in the molten material, as seems to be the condition in the gaseous emissions from active volcanoes, or on the other hand might be set free from limestones by influence of heat or from chemical reaction induced by the deep-seated igneous magma. Another explanation which has been frequently advanced by other students of the problem is that the gas is produced in the superficial zone by the action of a free acid, like sulphuric acid, upon the Paleozoic limestones which directly underlie the surface. The acid, it is thought, may be derived by oxidation of pyrite in the accompanying shales. As against this interpretation there is no evidence of a sufficient supply of free acid to cause the decomposition of limestone on a scale demanded by the quantities of carbon dioxide present, or of the resultant calcium sulphate, of which quantities would be left behind as gypsum, since the amount of dissolved sulphates in the waters is small. No doubt the solvent properties of the carbon dioxide are responsible for much of the saline matter carried by the waters.

The relative amount of carbon dioxide in the Saratoga waters varies considerably in the individual wells. As many as five or six volumes are reported to have been present in some of the best wells drilled by the gas companies whose properties were situated to the south of the city and at Geysers. The general average may be taken at two or three volumes. At atmospheric pressure water is able to retain one volume of the gas, but its solvent power greatly increases with pressure, which accounts for the presence of such large quantities in some of the naturally stored waters that are under hydrostatic load. As the water comes to the surface and pressure is released the gas is evolved and causes the lively boiling noticed in the Saratoga waters as they issue from the wells.

In the most active period of the carbonic gas industry, in the four years immediately preceding 1908, when the further production was enjoined by law, there were five gas collecting plants that employed about thirty wells altogether for the purpose. The product ranged from 4,000,000 to 5,000,000 pounds a year. Pumps were used to bring the water to the surface where the gas was separated and conducted through a pipe to the gas holders for storage previous to liquifying and charging into cylinders.

## CEMENT

### Portland Cement

Since its establishment in the State in 1881 the portland cement industry has made rapid strides and has become one of the most important mineral industries of the State. In 1926 the shipments of portland cement amounted to 8,535,862 barrels valued at $14,864,066, as compared with 8,534,089 barrels valued at $14,967,-642 in 1925. The shipments in 1926 and the value in 1925 are the two largest ever recorded. The average net price a barrel of 376 pounds at points of shipment in 1926 was $1.74; in 1925, $1.75. The values as given are based on actual shipments since no definite prices can be given to stocks manufactured during the year and remaining unsold at its close. At the beginning of 1926, stocks of portland cement on hand amounted to 1,024,621 barrels. Production during the year amounted to 8,795,768 barrels, and after shipments during the year of 8,535,862 barrels the stocks on hand at the end of 1926 amounted to 1,284,527 barrels.

In shipments of portland cement in 1926 New York ranked fourth among the States, being preceded in order of bulk of shipments by Pennsylvania, 41,395,604 barrels; California, 13,660,078 barrels; and Michigan, 11,959,447 barrels.

Altogether in the United States 140 portland cement plants were in operation at the end of 1926. The total shipments amounted to 162,187,090 barrels with an average factory value of $1.71 a barrel—three cents under the average factory price of the New York cement plants. The range in factory prices for all states is comparatively small, from $1.59 in Kansas to $1.89 in Texas.

Although more than 8,000,000 barrels of portland cement were shipped from New York State plants during 1926, this amount fell far short of the State's needs. New York is the largest cement-consuming State, requiring approximately 20,000,000 barrels for the year, and exceeding requirements of any other state by more than 6,000,000 barrels. Imports of cement, largely from Pennsylvania, where raw supplies and especially fuel are abundant, make up the deficiency in local production.

In 1926 the locations of portland cement plants operating in the state were as follows:

1 *Catskill, Greene county.* North American Cement Corporation, Albany, N. Y. Previous to 1926 this plant was operated by the Acme Cement Corporation, Catskill, N. Y.

2 *Cementon, Greene county.* Alpha Portland Cement Company, Easton, Pa.

3 *Alsen, Greene county.* Lehigh Portland Cement Company, Allentown, Pa. Previous to 1925 this plant was operated by the Hudson Valley Portland Cement Corporation, Alsen, N. Y.

4 *Hudson, Columbia county.* Knickerbocker Portland Cement Company, Albany, N. Y.

5 *Hudson, Columbia county.* Atlas Portland Cement Company (New York and New England Cement and Lime Co.), 25 Broadway, New York, N. Y.

6 *Howes Cave, Schoharie county.* North American Portland Cement Corporation, Albany, N. Y. Previous to 1925 this plant was operated by the Helderberg Cement Company, Albany, N. Y.

7 *Glens Falls, Warren county.* Glens Falls Portland Cement Company, Glens Falls, N. Y.

8 *Jamesville, Onondaga county.* Alpha Portland Cement Company, Easton, Pa.

9 *Portland Point, Tompkins county.* Pennsylvania-Dixie Cement Corporation, Nazareth, Pa. Previous to 1926, this plant was operated by the Cayuga Operating Company, a subsidiary of the Pennsylvania Cement Company, 131 E. 46th st., New York, N. Y.

In the manufacture of portland cement all the above companies use local limestone and either clay or shale. The use of clay is reported by seven of the companies, the other two using shale. In addition to the limestone and clay or shale used in portland cement making, some gypsum is also required. This is supplied from the gypsum mines of western New York. According to reports received from producers, the 8,447,250 barrels of cement equivalent to 1,588,083 tons, manufactured in the State during 1926, required 2,415,198 tons of limestone, 198,700 tons of clay or shale and 45,000 to 50,000 tons of crude gypsum.

**New cement plants.** The completion of two new portland cement plants now in course of erection at Buffalo, which will reach the production stage by the middle of 1927, will greatly add to the mill capacity for production of portland cement in the State. As these plants contain a number of new and unusual features, including plant design and methods of manufacture, they will be briefly described.

One of the plants is that of the Great Lakes Portland Cement Corporation, of which Adam L. Beck is president. The plant, which is the largest constructed in recent years, has an annual capacity of

2,500,000 barrels, and is located near the southern city line of Buffalo, not far from the Lackawanna plant of the Bethlehem Steel Company. By reason of location on Buffalo harbor and the Union canal extension of the harbor, deep water transportation is available through the lakes. Railroad connections and improved highways afford means for land shipments. The limestone is delivered in crushed form by boat from quarries at Rogers City and Rockport, Mich. Shale is obtained by rail from Shaleton, 12 miles south of Buffalo, and gypsum from the nearby mines in western New York, some of which are but a few miles from Buffalo.

With the exception of the kiln building, the other buildings, eight in number, are of reinforced concrete, requiring 40,000 yards of concrete for their construction. The buildings are all erected on slag filled land, and 400,000 feet of piling were used for the foundation work. The corporation has an additional five acres for expansion.

The plant is electrically equipped throughout, the power being derived from Niagara Falls. Electric power is also used at the shale quarry. For power purposes at the plant, 168 electric motors with a horsepower rating of nearly 11,000 are available. Other equipment includes rotary kilns, coolers, combination grinding mills and 12 slurry storage tanks. Storage is provided by 16 cement silos each 33 feet in diameter and 80 feet high, having a total capacity of 350,000 barrels.

The other new portland cement plant at Buffalo is that of the Federal Portland Cement Company. The raw materials are slag and limestone. It is said to be the second plant in the United States to use slag as a raw material in the wet process and the first in the world designed to include slurry filters. The yearly capacity of the plant is 1,200,000 barrels. Production will begin about the middle of 1927.

**Early strength cements.** During the past few years there has appeared on the market new types of cement, notable for the fact that they acquire in 24 hours a similar degree of strength attained by ordinary portland cements in 28 days. A name applied to one type of this early strength or quick-hardening product is "high-alumina cement," so-called because of its high alumina content. The high percentage of alumina in this cement as compared with ordinary portland cement is clearly shown by comparison of the analyses as here quoted from a paper by P. H. Bates (Industrial and Engineering Chemistry, v. 18, no. 6, p. 554, June 1926).

*Portland Cement*

| | Per cent |
|---|---|
| $SiO_2$ | 22.0 |
| $Al_2O_3$ | 6.5 |
| $Fe_2O_3$ | 3.0 |
| CaO | 63.0 |
| MgO | 3.0 |
| $SO_3$ | 1.5 |
| Impurities | 1.0 |

*High-Alumina Cement*

| | Per cent |
|---|---|
| $SiO_2$ | 5.0 |
| $Al_2O_3$ | 42.0 |
| $Fe_2O_3$ | 10.0 |
| CaO | 42.0 |
| Impurities | 1.0 |

In order to obtain the high alumina content in cement, it is necessary that some special raw material be employed in the mix. This is generally accomplished by the use of bauxite, which replaces clay or shale in the usual formula. On account of the slow initial setting of alumina cement, as distinct from quick-hardening properties, no gypsum is required in its manufacture. Ordinary portland cement with a higher lime content requires before grinding of the clinker an addition of 2½ to 3 per cent of gypsum to retard what is called the first or initial setting, and here again distinction must be made between setting and hardening, the latter term relating to the rate at which the cement acquires strength. In the manufacture of alumina cement the raw materials are reduced to a fused mass, and this gave rise to the name "fused cement" sometimes applied to cement with high alumina content. The absence of bauxite or other suitable minerals high in alumina in New York and adjacent states has made it necessary to obtain from distant sources the raw material or else import the high-alumina cement.

Another type of quick-hardening cement often designated as "super cement" is made of practically the same materials as ordinary portland cement, but with a slightly higher lime content. The constituents of the "super cements" are burned at a higher temperature, and are more finely ground in both the raw and calcined state.

At present only one firm in the State is manufacturing a quick-hardening cement. This is the Glens Falls Portland Cement Co., which markets its product under the trade name "Iron Clad Velo Cement." This is not a high-alumina cement, but at present, information is not available as to its chemical composition or the details of the process of manufacture.

## Natural Cement

During recent years the only outstanding development in the natural cement industry has been the completion of a new plant which started operations about the middle of 1926. The plant was constructed and is being operated by the Louisville Cement Company

of Louisville, Ky. Its location is in the town of Newstead, near Akron, Erie county, about 20 miles northeast of Buffalo.

In its operations the company uses natural cement rock, which previous to 1906 was the principal raw material used in cement manufacture in the State. The cement is burned in kilns with producer gas and the cement manufactured is of a nonstaining character, used chiefly as a mortar and marketed under the name "Brixment."

The only other natural cement plant, and the only one in operation in the State for a number of years prior to 1926, is located in the once famous Rosendale cement district of Ulster county. It is operated by A. J. Snyder & Co. of Rosendale, N. Y. As there are but two producers of natural cement, figures of production can not be given.

The decline in the manufacture of natural cement dates from about 1900, but it was not until 1906 that the production of portland cement exceeded that of natural cement. The production for the latter year was: Portland cement, 2,423,374 barrels; natural cement, 1,691,374 barrels. In 1905 the output of natural cement exceeded that of portland cement by 138,876 barrels.

**Production and shipments of portland cement in New York since 1917**

| YEAR | PRODUCTION BARRELS | SHIPMENTS | |
|---|---|---|---|
| | | Barrels | Value |
| 1917 | 5 417 530 | 5 408 726 | $7 050 656 |
| 1918 | 4 095 588 | 4 074 159 | 6 568 746 |
| 1919 | 4 383 579 | 4 441 250 | 7 700 406 |
| 1920 | 5 885 058 | 6 049 150 | 12 206 698 |
| 1921 | 5 294 188 | 4 993 341 | 9 403 015 |
| 1922 | 5 922 706 | 6 194 663 | 10 694 426 |
| 1923 | 6 990 174 | 6 853 062 | 12 834 471 |
| 1924 | 7 571 856 | 7 435 875 | 13 460 594 |
| 1925 | 8 769 584 | 8 534 089 | 14 967 642 |
| 1926 | 8 795 768 | 8 535 862 | 14 864 066 |
| Total | 63 126 031 | 62 520 177 | $109 750 720 |

## CLAY MATERIALS

In 1926 the value of all kinds of clay products, which include various types of brick, pottery, terra cotta and other kinds of clay wares, manufactured in the State amounted to $29,181,899. The importance of the clay products industry is evident when it is considered that in value of products it represents more than one-fourth of the entire mineral output of the State. The growth of the industry during the past ten years is due largely to the increased production of common brick and to a lesser extent to the increased production of pottery.

### Common Brick

The value of common brick produced in the State in 1926 amounted to more than one-half of the total value of all clay products and was the largest individual item in New York's mineral production. The output totalled 1,302,465,000 brick with a value of $17,296,977. This represents an increase in production over 1925 of 257,790,000 brick and an increase in value of $4,578,482. The price of brick in 1925 was $12.17 a thousand; in 1926 the price was $13.28 a thousand.

In point of value the 1926 output was the largest ever recorded and in the number of brick produced the largest since 1910. The year 1910 was one of extremely low price for brick, $4.70 a thousand, the lowest price recorded within a period of 25 years. Although in the years immediately following 1910 the price of brick gradually increased, the production fell off and by 1914 less than 1,000,000,000 brick were being manufactured annually. In 1918, with a price of $9.72 a thousand, only 313,638,000 common brick were produced. The low production in 1918 can be partly attributed to war conditions. Following 1918 the common brick industry in the State has shown considerable recovery, and in 1924 production had once more exceeded 1,000,000,000 brick. Although during the past ten years and for a number of years previously there has been a decrease in the number of brick manufacturing establishments, an increase in production through more modern methods has been brought about in a number of the brick manufacturing plants.

The number of plants operating during the past ten years in the State together with the quantity, value and price a thousand of the brick produced is given in the accompanying table.

The Hudson river district comprising the counties of Albany, Columbia, Dutchess, Greene, Orange, Rensselaer, Rockland and Ulster is one of the most important brick-producing sections in the

United States. In this district, brick-making clays are found on both banks of the Hudson from Albany and Rensselaer counties at the north to Rockland county on the south. The district possesses the advantages of barge shipments mainly to the New York City markets. In addition to shipments by water, railroads are also available for shipment from either bank of the Hudson. In Albany and Rensselaer counties a considerable quantity of the output is used locally, and during recent years the motor truck has extended the market laterally throughout the district.

Of the 92 establishments reporting production of common brick in the State in 1926, 68 were located in the Hudson river district and 24 in other parts of the State. The output of the 24 plants amounted to but 217,461,000 brick valued at $2,771,780. The accompanying tables present in concise form the counties in which common brick plants are located, together with the number of operators and figures of production.

## Face Brick

Face brick is manufactured in Erie, Broome and Onondaga counties. In 1926 the output reported by four firms, one of which operated two plants, amounted to 20,546,000 brick valued at $306,902. In 1925 five plants reported production of 29,336,000 valued at $475,735. The price a thousand in 1925 was $16.22; in 1926 it was $14.94.

In the general tables giving mineral production in New York in 1925 and 1926 the output and value of face brick is combined with that of common brick under the item building brick.

## Fire Brick

In 1926 but two firms reported the manufacture of fire brick and figures of production and values can not be given. In 1925 four firms reported a production of 5,159,000 brick valued at $428,050. The price a thousand was $82.97.

## Building Tile

The production of hollow building tile in 1926 amounted to 63,089 tons valued at $445,117. In 1925 the production was 67,397 tons valued at $445,722. Seven establishments reported production for both years.

## Drain Tile

Five establishments reported production of drain tile in 1926. The output amounted to 4934 tons valued at $39,273. In 1925 there were six establishments with an output of 7995 tons valued at $63,627.

## Terra Cotta

The 1926 production of architectural terra cotta amounted to 16,793 tons valued at $1,954,473. The corresponding figures for 1925 are 16,083 tons valued at $1,886,030. The price a ton in 1926 was $116.39; in 1925 it was $117.27.

## Stove Lining

In 1926 there were but two producers of stove lining. In 1925, when there were three producers, the output amounted to 1115 tons valued at $68,390.

## Refractory Cement

Refractory cement was produced by five firms both in 1925 and 1926. The output in 1926 amounted to 2180 tons valued at $182,846. The corresponding figures for 1925 are 2032 tons valued at $208,232.

Other clay products, of which there were only one or two producers, and for which the output and values can not be given, include floor tile, ceramic mosaic tile, vitrified paving brick, sewer pipe, flue lining, and wall coping.

## Pottery

The total value of pottery produced in 1926 was $7,505,037. In 1925 the value was $7,375,907. The items which make up the totals are given in the table below:

| PRODUCT | 1925 | 1926 |
|---|---|---|
| Hotel china | $3 675 665 | $3 942 692 |
| Porcelain electric supplies | 3 146 498 | 2 948 878 |
| Saggers | 212 637 | 384 726 |
| Other pottery products | 341 107 | 228 741 |
| Total | $7 375 907 | $7 505 037 |

Under "other pottery products" in the table are included red earthenware, refrigerator linings, clay pipes and some special grades of pottery including ornamental objects, such as vases and lamps.

Production of clay products in New York since 1917

| YEAR | COMMON BRICK | PAVING BRICK | TERRA COTTA | POTTERY | OTHER KINDS | TOTAL |
|---|---|---|---|---|---|---|
| 1917 | $5 068 028 | $248 506 | $813 112 | $4 076 817 | $1 221 936 | $11 428 399 |
| 1918 | 3 050 037 | 113 395 | 426 724 | 6 047 472 | 1 255 326 | 10 892 954 |
| 1919 | 6 374 979 | 252 948 | 629 213 | 5 633 355 | 1 578 091 | 14 468 586 |
| 1920 | 8 346 530 | 159 981 | 1 294 534 | 7 308 283 | 2 004 356 | 19 113 684 |
| 1921 | 7 351 116 | 225 734 | 1 166 560 | 6 789 055 | 1 899 621 | 17 432 086 |
| 1922 | 11 571 363 | 263 484 | 1 248 440 | 5 685 884 | 1 779 638 | 20 548 809 |
| 1923 | 14 706 098 | 226 642 | 1 773 039 | 6 289 381 | 2 789 690 | 25 784 850 |
| 1924 | 13 683 606 | 249 620 | 1 639 424 | 8 421 523 | 2 224 366 | 26 218 539 |
| 1925 | 12 690 264 | 252 585 | 1 886 030 | 7 375 907 | 2 578 799 | 24 783 585 |
| 1926 | 17 296 977 | 208 648 | 1 954 473 | 7 505 037 | 2 216 764 | 29 181 899 |
| Total | $100 138 998 | $2 201 543 | $12 831 549 | $65 132 714 | $19 548 587 | $199 853 391 |

Production of common brick in New York since 1917

| YEAR | NUMBER OF OPERATORS | QUANTITY | VALUE | VALUE A THOUSAND |
|---|---|---|---|---|
| 1917 | 129 | 656 508 000 | $5 068 028 | $7 72 |
| 1918 | 105 | 313 638 000 | 3 050 037 | 9 72 |
| 1919 | 85 | 479 405 000 | 6 374 979 | 13 30 |
| 1920 | 87 | 488 703 000 | 8 346 530 | 17 08 |
| 1921 | 84 | 620 628 000 | 7 351 116 | 11 84 |
| 1922 | 82 | 814 376 000 | 11 571 363 | 14 20 |
| 1923 | 91 | 974 586 000 | 14 706 098 | 15 09 |
| 1924 | 87 | 1 029 667 000 | 13 683 606 | 13 28 |
| 1925 | 86 | 1 042 791 000 | 12 690 264 | 12 17 |
| 1926 | 92 | 1 302 465 000 | 17 296 977 | 13 28 |

Production of common brick in the Hudson river region since 1904

| YEAR | NUMBER OF OPERATORS | OUTPUT | VALUE | PRICE A THOUSAND |
|---|---|---|---|---|
| 1904 | 110 | 1 009 838 000 | $5 846 097 | $5 79 |
| 1905 | 119 | 1 219 318 000 | 8 191 211 | 6 54 |
| 1906 | 131 | 1 230 692 000 | 7 352 377 | 5 98 |
| 1907 | 122 | 1 051 907 000 | 5 471 713 | 5 20 |
| 1908 | 114 | 817 459 000 | 3 812 511 | 4 75 |
| 1909 | 119 | 1 218 784 000 | 6 433 190 | 5 28 |
| 1910 | 114 | 1 102 265 000 | 5 000 662 | 4 54 |
| 1911 | 96 | 807 713 000 | 3 857 143 | 4 78 |
| 1912 | 102 | 900 344 000 | 5 037 438 | 5 60 |
| 1913 | 106 | 788 731 000 | 4 176 406 | 5 37 |
| 1914 | 98 | 709 877 000 | 3 346 430 | 4 77 |
| 1915 | 85 | 693 655 000 | 3 531 413 | 5 09 |
| 1916 | 85 | 691 485 000 | 4 485 526 | 6 48 |
| 1917 | 85 | 467 044 000 | 3 423 573 | 7 33 |
| 1918 | 66 | 211 574 000 | 1 950 611 | 9 22 |
| 1919 | 66 | 328 157 000 | 4 387 639 | 13 37 |
| 1920 | 67 | 334 395 000 | 5 697 680 | 17 04 |
| 1921 | 54 | 481 677 000 | 5 739 868 | 11 92 |
| 1922 | 52 | 580 468 000 | 8 363 171 | 14 41 |
| 1923 | 63 | 729 469 000 | 11 052 196 | 15 15 |
| 1924 | 61 | 798 036 000 | 10 648 132 | 13 34 |
| 1925 | 63 | 817 204 000 | 9 992 230 | 12 21 |
| 1926 | 68 | 1 085 004 000 | 14 525 197 | 13 39 |

Output of common brick in the Hudson river region for 1925

| COUNTY | NUMBER OF OPERATORS | OUTPUT | VALUE | PRICE A THOUSAND |
|---|---|---|---|---|
| Albany | 11 | 113 234 000 | $1 442 923 | $12 74 |
| Columbia | 3 | 70 689 000 | 968 885 | 13 71 |
| Dutchess | 12 | 79 233 000 | 977 621 | 12 34 |
| Greene | 4 | 36 396 000 | 427 967 | 11 76 |
| Orange [a] | 2 | ............. | .......... | ......... |
| Rensselaer | 2 | 128 314 000 | 1 502 492 | 11 71 |
| Rockland | 10 | 101 317 000 | 1 294 183 | 12 77 |
| Ulster | 19 | 288 021 000 | 3 378 159 | 11 73 |
| Total | 63 | 817 204 000 | $9 992 230 | $12 21 |

a The output of Orange county is included with that of Rensselaer county.

**Output of common brick in the Hudson river region for 1926**

| COUNTY | NUMBER OF OPERATORS | OUTPUT | VALUE | PRICE A THOUSAND |
|---|---|---|---|---|
| Albany | 11 | 140 478 000 | $1 902 089 | $13 54 |
| Columbia | 3 | 100 989 000 | 1 407 946 | 13 94 |
| Dutchess | 13 | 120 747 000 | 1 580 158 | 13 09 |
| Greene | 4 | 45 073 000 | 597 347 | 11 03 |
| Orange | 2 | 104 310 000 | 1 404 950 | 13 47 |
| Rensselaer | 3 | 80 372 000 | 971 862 | 11 88 |
| Rockland | 10 | 136 296 000 | 1 866 784 | 13 70 |
| Ulster | 21 | 356 739 000 | 4 794 061 | 13 44 |
| Westchester [a] | 1 | ............ | .......... | ......... |
| Total | 68 | 1 085 004 000 | $14 525 197 | $13 39 |

*a* The output and value of Westchester county is included with that of Orange county.

**Production of common brick in New York State outside of the Hudson river region for 1925**

| COUNTY | NUMBER OF OPERATORS | OUTPUT | VALUE |
|---|---|---|---|
| Cattaraugus | 1 | 19 817 000 | $234 921 |
| Chautauqua [a] | 1 | ............ | ........... |
| Chemung [a] | 1 | ............ | ........... |
| Erie | 4 | 31 974 000 | 355 517 |
| Monroe [b] | 1 | ............ | ........... |
| Montgomery [c] | 1 | ............ | ........... |
| Nassau [d] | 1 | ............ | ........... |
| Oneida | 2 | 22 349 000 | 370 933 |
| Onondaga | 3 | 11 360 000 | 188 560 |
| Richmond | 2 | 35 724 000 | 384 360 |
| Saratoga | 4 | 84 133 000 | 878 983 |
| Suffolk | 2 | 20 230 000 | 284 760 |
| Total | 23 | 225 587 000 | $2 698 034 |

*a* Included in Cattaraugus county.
*b* Included in Oneida county.
*c* Included in Richmond county.
*d* Included in Suffolk county.

**Output of common brick outside of the Hudson river region for 1926**

| COUNTY | NUMBER OF OPERATORS | OUTPUT | VALUE |
|---|---|---|---|
| Broome | 1 | 26 557 000 | $364 998 |
| Cattaraugus [a] | 1 | ........... | ........... |
| Chautauqua [b] | 1 | ........... | ........... |
| Chemung [c] | 1 | ........... | ........... |
| Erie | 5 | 33 951 000 | 460 586 |
| Monroe [d] | 1 | ........... | ........... |
| Montgomery [e] | 1 | ........... | ........... |
| Nassau [d] | 1 | ........... | ........... |
| Oneida | 2 | 7 130 000 | 102 820 |
| Onondaga | 2 | 19 391 000 | 269 912 |
| Richmond | 2 | 33 186 000 | 386 380 |
| Saratoga | 3 | 63 461 000 | 776 194 |
| St Lawrence [d] | 1 | ........... | ........... |
| Suffolk | 2 | 33 785 000 | 410 890 |
| Total | 24 | 217 461 000 | $2 771 780 |

*a* Included in Richmond county.
*b* Included in Oneida county.
*c* Included in Suffolk county.
*d* Included in Broome county.
*e* Included in Onondaga county.

## CRUDE CLAY

In addition to the clay that is mined and used by manufacturers in the clay products industry, such as brick and tile, and in the portland cement industry, a comparatively small amount of clay is produced and sold as crude or raw clay. Clay designated as crude or raw is shipped in a crude state without the addition of other ingredients, although in some cases the clay is subjected to a certain preliminary treatment such as drying.

With few exceptions, clays that are mined and shipped possess certain properties not found in ordinary clays that adapt them to special uses. Among these special clays are the well-known Albany slip clays, the mining of which is confined at present within the city limits of Albany. The slip clays obtained at Albany are widely known for their use as a glaze for stoneware and electric insulators, and shipments have been made to all parts of the country. The Albany slip clay is easily fusible and forms an even-colored natural glaze, which does not crack.

During recent years there has been developed a growing market for the easily fusible slip clay for use as a binder in the manufacture

of artificial abrasives. The quantity now used for this purpose greatly exceeds the amount sold for glazing purposes.

In addition to the Albany slip clays, the white plastic fire clays of Staten Island are the only other clays of importance in the State that have been mined and sold as special clays. The production and value of crude clay given in the table represents largely slip clay, except for the year 1926, when increased sales of fire clay, together with some special shipments of ordinary clays, which usually do not enter into the production totals, accounts for the large figures of that year.

**Production of crude clay**

| YEAR | TONS | VALUE |
|---|---|---|
| 1920 | 8 545 | $43 672 |
| 1921 | 4 247 | 16 423 |
| 1922 | 5 976 | 20 463 |
| 1923 | 8 247 | 43 701 |
| 1924 | 5 948 | 31 238 |
| 1925 | 7 503 | 47 637 |
| 1926 | 13 688 | 98 616 |

## DIATOMACEOUS EARTH

Diatomaceous earth, also called infusorial earth, is composed of the siliceous skeletal remains of minute aquatic plants known as diatoms. In general appearance diatomaceous earth, which is really anhydrous silica, resembles chalk or fine marl, but it can be easily distinguished from them by the fact that it does not effervesce when acid is applied to it. Diatomaceous earth is sometimes confused with tripoli, which is also a light porous siliceous material. Tripoli, some forms of which are called "rottenstone," results from the disintegration of a sedimentary rock, by the leaching of calcareous material from siliceous limestone or from a calcareous chert. Tripoli, however, may have a diatomaceous nature when the parent rock contains fossil diatoms. Pumice, or pumice stone, is a finely fragmental volcanic glass or dust. In large fragments it is very cellular and so light that it will float on water. Only in the powdered state need pumice be confused with diatomaceous earth or tripoli.

The best known deposits of diatomaceous earth are found in some of the Adirondack lakes, particularly those in northern Herkimer county. Among these is White Lead lake, where operations are being carried on by the Adirondack Diatomaceous Earth Company, of

Herkimer, N. Y. Other lakes in the vicinity that contain deposits include Clear, Big Crooked, Hawk and Chub lakes, Roilly pond and some other small bodies of water. The amount of diatomaceous earth present in these lakes is probably not less than two or three million cubic yards, but no actual surveys have been made on which a reliable estimate can be based. In thickness the deposits are said to be as much as 30 feet in some places, but the average thickness no doubt is considerably less. Diatomaceous earth is found not only in existing lakes and ponds but also in extinct lake bottoms, where the deposits are usually concealed by the accumulation of muck, or other material.

Although diatomaceous earth has a score of uses, the entire production of the State at present is used in the manufacture of silver polish. For this purpose material of uniform grade and fineness is required and consequently commands a high price. An important use for diatomaceous earth which has been developed within the past few years is its application with cement in concrete aggregate, which gives the latter greater workability without the addition of excess water. For this purpose the addition of 2 to 5 per cent of the weight of the cement used is recommended. The percentage of diatomaceous earth employed is dependent on the proportions of the concrete mix.

**Production of diatomaceous earth since 1922**

| YEAR | TONS | VALUE |
|---|---|---|
| 1922 | 216 | $13 790 |
| 1923 | 208 | 13 378 |
| 1924 | 199 | 12 995 |
| 1925 | 114 | 7 528 |
| 1926 | 187 | 12 770 |

## EMERY

One of the few localities for the occurrence of emery in the United States is near Peekskill, Westchester county, where this material has been obtained in commercial quantity for many years. Massachusetts has contributed a small output in times past from deposits near Chester in the Berkshires, but the mines are now inactive and possibly will not resume operations. The third and remaining locality is at Whittle Station, Pittsylvania county, Virginia, which has made small shipments since about 1918.

The supplies of emery from domestic sources represent only a small fraction of the market requirements under normal conditions. The annual shipments do not exceed about a thousand tons as a rule, although during the war they ran up to around 15,000 tons, when importations temporarily were reduced. The chief sources of imports are Greece and Turkey which have a practical monopoly of the world's trade.

Emery is not a single mineral but a rock of somewhat variable mineral composition. The most important abrasive constituent found in it is corundum, the common form of the sapphire ($Al_2O_3$), which is superior to all other mineral species in hardness except the diamond. The per cent of corundum present ranges within rather wide limits, from about 35 to 60 per cent in the foreign ores, and even more in the domestic sorts. Magnetite is nearly always present, and occasionally such ingredients as spinel, garnet, quartz and feldspar. The rock is prepared for use by crushing and grading into sizes.

The Peekskill deposits are found within the area of igneous rocks of the so-called Cortlandt series that occurs to the southeast of that village. The rocks belong to the basic class, low in silica, and include diorite, gabbro, norite, peridotite and pyroxenite. The area is of oval outline, about seven miles in diameter east and west and five miles from north to south. The bodies of emery constitute bands and irregular masses distributed without rule within the different materials. Most of those opened for production occur in the eastern part, northeast of Pleasantside and further south near Dickerson pond and Salt hill. Mining is carried on mostly by open cutting along the outcrop, without much deep work through shafts. The ore when broken is sorted roughly according to appearance and probable content of corundum and hauled to Peekskill for shipment.

**Production of emery in New York since 1917**

| YEAR | SHORT TONS | VALUE |
|---|---|---|
| 1917 | 15 941 | $170 223 |
| 1918 | 8 183 | 61 660 |
| 1919 | 1 563 | 13 459 |
| 1920 | 1 596 | 14 375 |
| 1921 } 1922 } | 817 | 6 421 |
| 1923 | 461 | 3 427 |
| 1924 | 1 610 | 11 426 |
| 1925 | 769 | 5 907 |
| 1926 | 386 | 3 641 |

## FELDSPAR

The quarrying and grinding of feldspar lend support to a small industry that has been carried on in New York State for many years. The product is essential to the manufacture of white pottery, glazed tile, enamel ware and certain grades of glass, and finds ready sale in local and nearby establishments. Besides the enterprises that produce feldspar for grinding or for shipment in crude form, there are several plants engaged in milling feldspar which is brought in from other states and Canada to supplement the local supplies.

Feldspar is a constituent of the crystalline rocks, and as such occurs abundantly in most of the Adirondack formations and in many of those in the southeastern Highlands. Practically the only commercial source of the mineral is the coarse-grained granites or pegmatites that accompany the common granite intrusions as offshoots of the latter or in minor bodies within the main intrusions. These dikes and bosses of pegmatite are made up of feldspar, quartz and mica like the parent mass, but the minerals are segregated in individual crystals or aggregates instead of being intimately intermixed and the crystals attain a large size. With ordinary granite the separation of the different constituents so as to procure clean fractions is impractical. For most uses it is quite essential that the feldspar be free of admixture, especially of iron-bearing minerals.

The feldspar found in pegmatites includes, as a rule, more than one variety. The commoner kinds are the potash varieties orthoclase and microcline, which differ from each other only in crystallization, and albite which is a soda feldspar. In addition varieties like oligoclase and andesine which contain soda and lime may occur. The potash feldspars are most sought for in pottery manufacture, but albite is desirable for certain purposes on account of its lower melting point. The lime-soda feldspars are not much used in pottery. The chemical characteristics of the feldspars are determinable without elaborate analysis by microscopic tests. The changes in composition are accompanied by physical or crystallographic variations which can be readily measured with a suitable instrument.

Quartz is an important constituent of all pegmatites, and when it is obtainable in pure state has considerable value. It is thus a byproduct of some feldspar quarries. If intergrown with the feldspar to any extent, it detracts from the selling price of the latter, and most buyers place a maximum limit upon the per cent of admixed quartz. If this is exceeded the material is subject to rejection or is penalized. Yet, quartz or other forms of silica are an essential part of the body of white wares.

The mica found in pegmatites may include muscovite, the light or transparent variety, or biotite, the black iron-bearing type. A number of other minerals are occasionally represented, like hornblende, pyroxene, tourmaline, magnetite, pyrite, epidote, allanite, titanite and beryl. Of these, only beryl has any commercial value. At the same time, their presence may be of determinative importance with reference to the utilization of the pegmatite, since if widely distributed they may preclude the extraction of merchantable feldspar.

Feldspar is used to some extent as an abrasive in the form of scouring soaps and powders. For that purpose it is ground to an impalpable powder. It is also employed in the manufacture of abrasive wheels, as a binder for the harder components.

Crushed unsorted pegmatite is employed for artificial stone which is made to imitate granite; also as a coating on stucco and as the mineral aggregate in prepared roofing. The production of this material in recent years has been included with granite.

## Quarry Localities

There are innumerable pegmatite occurrences in the Adirondack region, especially in the area which surrounds the central anorthosite massive. They accompany the large intrusions of granite and syenite which are widely developed on all sides of this central uplift. It is only here and there, however, that the bodies attain large dimensions and at the same time carry a sufficient proportion of feldspar so segregated that they can be profitably exploited. Many occurrences are too remote to be given attention. The prices obtained for the product do not admit of long haulage.

On the east side of the Adirondacks feldspar has been quarried at several places in the vicinity of Crown Point and Ticonderoga, Essex county. The Crown Point Spar Co. operates a large deposit just south of Crown Point village, and a mile back from Lake Champlain. It produces mostly crushed pegmatite but has shipped pottery spar and some mica. Eight miles back from Crown Point, near Towner pond, is the Roe property which has yielded an excellent grade of pottery feldspar, but is rather remote for economical operation. About two miles west of Ticonderoga is the Barrett quarry, formerly productive, and between Ticonderoga and Montcalm landing is another occurrence that has been worked in years past. The old Ashley quarry, two and one-half miles northwest of Fort Ann, has produced a good grade of pottery feldspar. Near Chestertown, Warren county, is an occurrence once worked for muscovite, as well as for feldspar.

In the southern Adirondacks, quarries have been worked in the town of Mayfield, Fulton county; town of Edinburg, Saratoga county; and three miles southwest of Corinth station, Saratoga county. The occurrence in the Mayfield quarries yielded mostly albite which contains soda in place of the potash characteristic of most pottery material. Many other localities might be cited for this region, but the ones named represent the chief sources of marketed feldspar.

In the western and northern Adirondacks, the occurrences are generally too remote from the railroad to be of possible value at present. An exception to this statement is the quarry of the Green Hill Mining Co. in the town of De Kalb, St Lawrence county, in an outlying area of the Adirondack formations crossed by the railroad, that has produced large quantities of pottery material and is still active.

Of the southeastern Highlands region, the principal quarries are those in the town of Bedford, northern Westchester county. They include the Kinkel, Hobby and Bullock properties, of which the first named is the best known and one of the oldest and most productive operations in the country. The shipments include first-grade potash feldspar, albite, and vein quartz. The locality is also the source of fine specimens of beryl and tourmaline, besides several rare uranium minerals. In recent years the Bedford Mining Co. Inc., has worked the deposits.

## Production

The accompanying table gives the recent shipments of feldspar from local quarries, combined with those of quartz, which in some years has not been separately reported. Feldspar constitutes the larger part of the totals, both of quantity and value. Activity varies from year to year according to market conditions, but shows no well-defined trend toward expansion.

**Shipments of feldspar and quartz since 1919**

| YEAR | SHORT TONS | VALUE |
|---|---|---|
| 1919 | 10 412 | $84 901 |
| 1920 | 22 291 | 166 869 |
| 1921 | 11 577 | 102 094 |
| 1922 | 14 188 | 90 968 |
| 1923 | 18 520 | 135 177 |
| 1924 | 17 686 | 120 739 |
| 1925 | 13 600 | 77 922 |
| 1926 | 19 514 | 170 986 |

## GARNET

Garnet for abrasive uses is obtained in the vicinity of North Creek, Warren county. Its production and preparation constitute a specialized branch of the mineral industry which has been carried on there for many years. The mineral itself is of course very common in all regions where old crystalline rocks occur, and although many attempts have been made to establish similar enterprises elsewhere than in the Adirondacks, they have not led to any considerable success in the way of permanent production. The market possibilities, it would appear, do not encourage additional developments; in fact the productive capacity of the present establishments considerably exceeds the usual trade demands.

The occurrence of garnet in the North Creek district has been set forth in previous issues of this bulletin and in other reports of the New York State Museum, so that no detailed description is necessary at this time. The more valuable deposits consist of disseminated crystals and crystal aggregates within certain bands or zones of the country rocks. The proportions of garnet to the rock mass varies from a few per cent up to 10 or 12 per cent and in a few instances to even larger figures. From 5 to 10 per cent is the general average. The associated minerals which make up the main rock types consist of feldspar, hornblende, pyroxene, mica and quartz, for the most part. The garnet crystals are of all sizes, from a fraction of an inch in diameter to those measuring a foot or more across and that yield up to a ton or more of mineral in various sizes of fragments. A characteristic of practically all of the deposits is that the garnet shows well-developed lamination or fracture planes so as to break down or crumble readily when freed from its matrix, but the fragments so produced do not admit of further indefinite reduction like minerals that possess a cleavage structure. This lamination is at times marked by thin films of some secondary mineral like pyrite deposited on the garnet surfaces.

In the early days of mining the garnet was produced largely by hand picking, which was facilitated by this characteristic of yielding to slight pressure when the crystals were once exposed. The rock was drilled and broken down to suitable size for releasing the garnet and the latter was sorted out from the rest of the material with the aid of cobbing tools to secure the garnet from the more deeply embedded crystals. Such mineral was called pocket garnet or shell garnet. This method of hand sorting was practised on Gore mountain until recently, as the large size of the crystals and their relative

abundance in that deposit made it practicable in competition with mechanical treatment of rock of lower yield. The use of mechanical crushers and concentraters has now been generally adopted and has so increased the capacity of the enterprises that operations need be carried on only for part of the year to meet the requirements.

Besides the mines of the North Creek district, other occurrences in the Adirondacks have received more or less attention. One of these is in northern Essex county, about six miles south of Keeseville on the Clinton county border. The garnet, with a small admixture of green pyroxene, constitutes a rock of itself, so that it could be quarried and shipped as lump without special sorting or other preparation. The occurrence, however, is rather limited, and the garnet lacks some of the valuable characteristics of the crystallized mineral. It has no well-developed fracture planes and breaks down to a granular product in which the individual particles show few smooth surfaces or sharp edges. Its admixture with pyroxene, a mineral of inferior hardness, also may be noted. The country rock of the occurrence is anorthosite, an igneous material consisting practically of the feldspar called labradorite, and the deposit probably represents an inclusion of some foreign rock caught up in the intrusion and converted through pressure and heat into the mixture of garnet and pyroxene. This would account for its purely local development.

Another locality from which garnet has been obtained is in St Lawrence county three miles north of Gouverneur. The mineral, a pale reddish or pinkish variety, is plentifully disseminated through a green feldspar-quartz rock of the sedimentary or Grenville series. At least one-fourth of the rock, and locally nearly one-half, consists of the garnet in grains of about one-fourth inch in diameter. The particles are of rounded outline and not sharply defined at the borders, so that when the rock is broken, the garnet does not separate cleanly from the gangue. It has a granular rather than laminated habit. The sizes obtained are all of the smaller diameters rather than a mixture of large and small particles, such as is desirable for most abrasive uses.

The Adirondack garnet is an iron-alumina variety, which approaches in chemical composition almandite. It contains, however, some magnesia and lime which indicates an isomorphous mixture with other varieties. It has a hardness on the mineral scale of 7.5 – 8 in the crystallized sorts obtained from the disseminated deposits of North Creek. The value of garnet as an abrasive has become well established.

The report by Myers and Anderson, Garnet: Its Mining, Milling and Utilization (Department of Commerce Bul. 256, 1925) gives an interesting discussion of the abrasive qualities of the mineral and its relative value as compared with other materials of its class:

Present activity in the mining of garnet has resulted from recognition of the unusual abrasive properties of the mineral. The bulk of the garnet mined for use as an abrasive has been almandite; rhodolite, pyrope, and andradite have been utilized to a lesser extent. Deposits of the other varieties which could produce a commercial tonnage of abrasive garnet are unknown. Abrasive garnet is utilized either in the form of a manufactured paper, similar to sandpaper, or as a loose grain or powder for grinding and polishing. The average hardness of abrasive garnet is 7.5, but some specimens have shown a hardness approaching 8.0. Quartz that is used for the manufacture of ordinary sandpaper is not as hard; it has a hardness of 7.0. The marked lack of any regular cleavage and the manner in which the mineral fractures affect the shape of the grains of crushed garnet and thereby influence its industrial use.

Although much garnet has a laminated structure, which furnishes parting planes along which the mineral separates when crushed, this structure can not be considered true cleavage because the garnet shows no further tendency to part regularly when it has once been separated into the plates formed by these laminations. Furthermore, this parting is purely mechanical and is not related to the crystallization. Garnet used as an abrasive has a fracture that is irregular to subconchoidal, consequently the grains of crushed garnet are irregular, many-angled particles which are roughly equidimensional and suggest modified cubes or tetrahedrons which have a multitude of sharp chisel-like cutting edges. As these grains break in use further sharp edges are produced. Garnet seems to have just enough brittleness to break under the strain of ordinary use rather than to wear down to a smooth surface.

Substances having a distinct conchoidal or shell-like fracture, of which glass is a typical example, shatter into fragments that tend to be flat and very thin. Although these flat particles retain very sharp cutting edges, it is impossible to arrange them on paper in such a manner that they will make an efficient abrasive. Either they tend to lie flat on the paper or else they project in long splinters which make deep scratches in the material being ground or polished. These scratches are highly objectionable, as their removal requires further grinding and polishing and thus increases the cost. Particles of garnet have enough flat surfaces to permit firm attachment to the paper backing; at the same time they expose a number of cutting edges which are practically in the same plane and therefore abrade evenly. Powdered garnet is used chiefly for grinding plate glass; here its greatest asset is its hardness, which enables it to abrade the softer glass with rapidity.

## Production

The accompanying table gives the shipments of garnet from the Adirondack mines for recent years. The figures represent the marketed totals rather than the actual mill yields, although there is no important difference between the two methods of calculation as a rule. The output has shown some gain over a period of years, with temporary setbacks at times corresponding to periods of depression or of competition with other sources of supply. The Adirondack production, however, constitutes by far the largest part of the tonnage available for the market, both of domestic garnet and of imports. Considerable quantities of the mineral were imported at one time from Spain for use in this country, but since 1918 this trade has been small and sporadic. New Hampshire and North Carolina are the only other States that have produced garnet in recent years.

The Adirondack garnet shippers include the North River Garnet Co., with a property on Thirteenth lake, Warren county; Barton Mines Corp., operating on Gore mountain, Warren county; Adirondack Garnet Products Co., Inc., with a property in the town of Minerva, Essex county; and the Warren County Garnet Mills, near Wevertown in Warren county. The Adirondack Garnet Products Co., Inc., began production in July 1926, having taken over the Crehore mine on the Indian lake road, formerly worked by the American Glue Co. The mill on the property has been re-equipped with crushing and concentrating machinery and the output is shipped in the form of concentrates.

**Shipments of garnet in New York since 1919**

| YEAR | SHORT TONS | VALUE |
|---|---|---|
| 1919 | 4 623 | $301 252 |
| 1920 | 4 276 | 359 425 |
| 1921 | 2 998 | 258 705 |
| 1922 | 6 654 | 546 879 |
| 1923 | 7 662 | 583 190 |
| 1924 | 7 428 | 623 472 |
| 1925 | 7 614 | 669 545 |
| 1926 | 5 812 | 494 050 |
| Total | 47 067 | $3 836 515 |

## GRAPHITE

This mineral has been mined on a limited scale for many years. Shipments from the Adirondack deposits were made in 1850, if not a little earlier, and for a considerable period they yielded most of the domestic output of high-grade crystalline graphite. Production during the late war helped to make up the deficiency in the available supplies arising from the curtailment of shipments from foreign sources, and it appeared that the domestic industry, stimulated by the new demands, would continue to hold a prominent place in the trade in the future. Recent mining, however, has not followed the anticipated course. At the close of the war the markets were flooded by the accumulated stocks from Ceylon and Madagascar to the demoralization of prices, which fell below the levels at which American mines could compete. As a consequence, the Adirondack mines with most of the other producers elsewhere in the country have had to suspend operations. The industry will hardly be revived so long as current conditions prevail. The advantages of the foreign producers depend largely upon low labor costs, for which the better mechanical equipment of the American mines does not appear to afford a sufficient offset.

The accompanying table presents the statistics of production so far as they are available. In the years 1919–21 the figures are not given to avoid revealing the individual totals. For the later period no production has been reported. There seems to be little likelihood of an immediate resumption of operations, unless an unexpected change should occur in the market conditions. These have shown some improvements during the past year or two, but not to an extent that would warrant reopening of the mines.

The Adirondack deposits are described in considerable detail by Alling (Mus. Bul. 199) and by others, in the publications of the New York State Museum. They represent two types of occurrences —contact metamorphic and disseminated.

The first type is exemplified by the Chilson hill (also called Lead hill) locality three miles northwest of Ticonderoga, where the first mining operations in the Adirondacks seem to have been undertaken, as mentioned by Beck in his Mineralogy of New York, published in 1842. The graphite, a coarse crystalline variety resembling the Ceylon product, is distributed in larger and smaller masses or pockets along the contact of sediments of Grenville age with intrusive granite. Handsome specimens suitable for museum display occur here. Bunches of practically pure graphite are found, but for the most

part it is intergrown with other minerals, like calcite, pyroxene, feldspar, quartz and scapolite, which have resulted from the metamorphism of the limestone by the granite. The graphite, no doubt, is of related origin. The distribution is too irregular for systematic mining, and the methods employed in extraction have been to sink pits on the outcrop and to follow the course of the deposits downward and laterally as far as they continued to yield payable material. The pits, chambers, drifts and shafts evidence considerable activity in mining, but after a fashion that is not practicable today.

The Grenville limestones in the interior of the Adirondacks frequently carry small bunches and veins similar to the above. Among the localities may be noted the Welch farm, three miles south of Mineville, Essex county; Newcomb and Minerva, Essex county; and Pottersville, Warren county.

The second type of occurrence, and the most available for large-scale working, consists of certain Grenville quartzites and schists that carry graphite as one of the characteristic minerals. The flakes or crystals are scattered evenly throughout the rock. The graphite content is seldom more than 5 or 6 per cent of the total mass, but as the strata themselves cover extensive areas and the graphite-bearing portion ranges up to 25 or 30 feet thick and even more, the quantity represented is large. Moreover, the conditions admit of easy systematic operations, with moderate mining costs. The main factor in successful enterprise is the treatment of the ore after it is mined. The crystals of graphite are thin and fragile and in crushing to release them from the quartz gangue a portion is so finely comminuted as to escape recovery by ordinary gravity methods. A satisfactory yield was attained, however, in some of the mills. The flotation method of separation has been applied in later years to graphite with considerable success.

The mines in the Adirondack region that have been productive in the past are listed below:

Chilson hill property, Essex county, formerly worked by the American Graphite Co., already noted. This is the single contact occurrence which has produced commercial quantities of graphite.

American mine of the Joseph Dixon Crucible Co., situated at Graphite, Warren county, five miles west of Hague, on Lake George. Operations were carried on for 40 or more years, ceasing in 1921. The ore was crushed and the graphite recovered in a local mill. The concentrates were then shipped to Ticonderoga for refining and preparation for the market. The production of this mine was larger than that of any other Adirondack property and probably its aggregate shipments exceeded those of any mine in the country.

Faxon mine, adjoining the American, and worked in later years in connection with it.

Lakeside mine, at Hague, also operated at one time by the Joseph Dixon Crucible Co.

Mines of the Crown Point Graphite Co., near Penfield pond and Paragon (Chilson) lake, Essex county, 10 miles northwest of Ticonderoga. They were last worked about 1910.

Mine of the Columbia Graphite Co., near Round pond, northwest of Ironville, town of Crown Point, Essex county. Operations were carried on in 1903 and 1904, when the company moved its plant to Rock pond, town of Ticonderoga.

Mine of the Columbia Graphite Co., at Rock pond, Essex county, worked in 1904 and 1905. Later the property was worked by Pettinos Brothers.

Mine of the International Graphite Co., Chester township, Warren county. Active about 1901.

Mine of the Rowland Graphite Co., six miles southwest of Riverside, Warren county. Worked at intervals from about 1901 to 1910.

Mines of the Adirondack Mining and Milling Co., west side of South bay, town of Dresden, Warren county, three miles due west of Whitehall. Worked between 1904 and 1907.

Mine of the Champlain Graphite Co., in same locality as the one just mentioned and worked at about the same time. Nearby was the property of the Silver Leaf Graphite Co., which prospected a deposit but did not erect a mill.

Mine of Hooper Brothers, about two miles west of South bay and five miles straight west of Whitehall, in town of Dresden, Warren county. It started operations in 1916 and was one of the important shippers in subsequent years. The concentrates produced in the mill were retreated in a plant at Whitehall.

Mine of the Glens Falls Graphite Co., near Conklingville, Saratoga county. Work began in 1906. In 1911 the Sacandaga Graphite Co. took over the property.

Mine of the Saratoga Graphite Co., one mile southwest of Kings Station town of Wilton, Saratoga county, and four miles north of Saratoga Springs. Operations began about 1910, and in 1914 the property was taken over by the Graphite Products Corp., which enlarged the capacity for mining and milling and continued work for a few years.

Mine of the Empire Graphite Co., four miles west of Kings, Saratoga county, first operated about 1907 and active during two or three years. About 1917 this property was taken over by the Flake Graphite Co.

Mine of the Macomb Graphite Co., near Popes Mills, St Lawrence county. This has been the only shipper of amorphous graphite in the State. Property contains crystalline grade also, the two occurring in same locality. The crystalline variety is of rather fine size. The mine has supplied some paint material and has been worked at different times since about 1907.

## Artificial Graphite

New York has a unique industry in the manufacture of artificial graphite which has been carried on at Niagara Falls since about 1900. The electric power generated from the falls is employed for the conversion of organic carbon materials like anthracite coal and coke made from petroleum residue into graphitic form which requires the high temperatures of an electric furnace to effect. The process is the invention of E. G. Acheson and the operations are maintained by the Acheson Graphite Co. Many different articles are made from the artificial product, including lubricants, paints, small crucibles and electrodes for electric and electro-metallurgical purposes. It is not a complete substitute for the natural mineral, although it fills satisfactorily some of the requirements.

**Production of graphite in New York since 1904**

| YEAR | POUNDS | VALUE |
|---|---|---|
| 1904 | 3 132 927 | $119 509 |
| 1905 | 3 897 616 | 142 948 |
| 1906 | 2 811 582 | 96 084 |
| 1907 | 2 950 000 | 106 951 |
| 1908 | 1 932 000 | 116 100 |
| 1909 | 2 342 000 | 140 140 |
| 1910 | 2 619 000 | 160 700 |
| 1911 | 2 510 000 | 137 750 |
| 1912 | 2 628 000 | 142 665 |
| 1913 | 2 250 000 | 112 500 |
| 1914 | 2 483 339 | 151 143 |
| 1915 | 2 500 000 | 162 000 |
| 1916 | *a* | *a* |
| 1917 | 2 941 040 | 261 548 |
| 1918 | 3 266 518 | 273 188 |
| 1919 | *a* | *a* |
| 1920 | *a* | *a* |
| 1921 | *a* | *a* |
| 1922–26 | Nil | ........ |

*a* Figures can not be published, there being less than three producers.

## GYPSUM

Rapid growth of the market for gypsum and a corresponding development of the production facilities and of manufacturing technology have characterized the recent record of this industry. The progress in some departments has been revolutionary. Since the issue of Museum Bulletin 143, Gypsum Deposits of New York, in 1910, the production of the mines has increased fourfold, while the value of the raw and finished products as shipped has grown about 15 times. Most of this gain has occurred in the past nine or ten years, that is, after the war.

The activities have given a greatly increased importance to the State's resources of gypsum, and it has been deemed an opportune time to undertake a more thorough investigation of the field than had been carried out hitherto in connection with the published accounts. A new survey accordingly was made by D. H. Newland in the latter part of 1927. In the course of the work the whole area from eastern Madison county to Buffalo was traversed, with attention given to practically all of the outcrops, quarries and mines, and to the results of recent exploration wherever available. The report has been made ready for publication, but owing to the lack of the necessary funds for printing, its appearance will be delayed. Meanwhile, a short summary of some of the more important features will be presented here.

### Historical

Gypsum has been mined or quarried in New York since about 1810. The local deposits were the first in the country to come under commercial development, and the original discovery at Camillus, Onondaga county, in 1792, was the earliest that has been put on record, seemingly, for any of the states. Gypsum was valued at that time for its agricultural uses. The opening of the deposits in central New York made available to the agricultural districts of the eastern country an abundance of the material at a cost much lower than that for rock obtained from Nova Scotia and France.

By 1838, when the first geological survey of the State was in progress, the gypsum beds of Madison, Onondaga, Cayuga, Ontario and Monroe counties were under active operation. The yearly product at that time was about 50,000 tons, all ground for land plaster. This appears to have been about the average yield for the next 50 years, until the introduction of the calcination process gave a fresh stimulus to the industry. Although calcined gypsum was manufac-

tured in the State from imported rock as early as about 1840, no serious attempts to use the local material for manufacture of plaster of paris were undertaken until 1892. In that year William D. Olmstead started calcination of the Oakfield gypsum, and his enterprise, proving both a technical and commercial success, marked the beginning of the industrial development that has since taken place. The production of agricultural gypsum continued to be the main support of mining, however, until the opening of the present century. In 1901 the shipments of calcined plasters exceeded 50,000 tons for the first time; they then overbalanced the output of a little more than 30,000 tons of agricultural gypsum reported for the same year and have since largely predominated in the totals.

For the next 15 years or so the industry had a steady but not particularly rapid development. In 1918 the total production of crude rock was 531,038 short tons with a value for all products shipped from the points of origin of $2,670,099. The ensuing eight years to 1926 showed an increase to 1,723,460 tons of mined rock with a value of $16,794,589 for the products. The indicated gain in value is particularly remarkable, when it is considered that the quoted prices for the different products were generally lower in 1926 than in 1918. The explanation for the growth, therefore, must be sought in the more advanced stage to which the manufacture of the products as a whole was carried in the later years, which is actually the situation disclosed by study of the industry.

The increasing use of gypsum in the building trades is the principal feature in the recent expansion of markets. The shipments for other requirements have shown no corresponding gains. The introduction of gypsum plaster board, wall board, tile and other processed materials for expediting the construction of both wood-frame and steel buildings has met with such general favor on the part of builders and architects as to lend practically a new phase to the manufacturing department. The possibilities in this field are as yet incompletely explored and hold great promise for the future of the business.

## Occurrence of Gypsum

The commercial deposits are restricted to a single continuous area which extends in the form of a narrow belt from the vicinity of the city of Oneida in Madison county into the limits of Buffalo and to the Niagara river. The length thus is about 165 miles. The gypsum is associated with dolomitic limestones and occurs in layers or beds interstratified with them. To this bedded series, which is a part of

the Salina formation, the term "Camillus" has been assigned after the town of that name in Onondaga county where the original gypsum discovery, as already noted, was made.

The width of the outcropping belt varies with the topography and thickness of the beds from less than a mile to four or five miles wide. The beds are inclined slightly toward the south, the average rate being from 30 to 50 feet to the mile. As a consequence the continuation of the beds is always found on the south side of the exposed area, where owing to the coming in of new and higher formations they quickly attain considerable depths. At a distance of from five to ten miles to the south of the outcrop on the average they are buried beneath 1000 feet or so of covering beds, and at about that depth a new element in the succession below the gypsum appears in the form of rock salt. This original associate of the carbonate and sulphate deposits has been carried away in solution from the upper reaches of the Camillus. The total thickness of the undiminished series ranges from about 250 feet to a maximum of 600 feet, which latter is attained in the Finger lakes region.

The occurrence of gypsum, or hydrated calcium sulphate, is not coextensive with the Camillus beds. Recent drilling and exploration have indicated that the deposits extend only a relatively short distance down the dip or to the south of the outcrop, where the depth from the surface does not much exceed 200 feet and in most places probably is well within that limit. Beyond such limiting depths the gypsum is succeeded by beds of anhydrite, which consists of calcium sulphate without water and is of no commercial value. The change from the one material to the other is not abrupt but a narrow zone of intermixed gypsum and anhydrite intervenes.

This feature naturally is of prime importance in the exploration of the resources; much misdirected effort has resulted in the past from neglect to recognize its bearing upon the distribution of gypsum. Another consequence is the limitation of the available supplies for future operations, as the common method in mining of developing new supplies by extension of the shafts in depth can not be practised to any extent in the gypsum district. In most places the entire extent of the beds on the dip can be worked through a single opening.

## Resources

The output of rock in later years has come almost entirely from the western part of the area, in Erie, Genesee and Monroe counties. All the plants that make calcined plasters and elaborated articles of

gypsum are situated within that region, which covers about 50 miles of the total stretch of 165 miles of the beds. The remaining area has yielded mostly agricultural and cement rock.

In Erie and Genesee counties mining operations have been directed toward exploitation of high-grade rock which carries 90 per cent or more of hydrated calcium sulphate and which occurs in a seam from three and one-half to five feet thick. Only a single seam of the kind has been formed at any one place. The area underlain by the original seam within the bounds of present exploration as approximately defined by the village of Oakfield, Genesee county, on the east, and Williamsville, Erie county, on the west, may be estimated at about 6500 acres, or about ten square miles. The average yield to the acre is about 12,000 short tons. The total contents of the area represented by high-grade rock is thus around 78,000,000 short tons. Some additions to this tonnage may come from future extensions to the east and west of the explored section, but it is not likely that any developments will occur to expand the above estimate by more than a mere fraction of the total. About 15,000,000 tons have already been removed from the ground and an additional tonnage must be set aside for rock that can not be recovered owing to poor roof conditions, unusually wet ground and other circumstances. There are perhaps 60,000,000 tons yet to be mined. These resources may be supplemented by a large but unknown quantity of low-grade material which occurs in one or more seams within the area, but which has not so far been used to any extent. The gypsum content of these additional seams is usually around 60 or 65 per cent.

In Monroe county there are two six-foot beds of gypsum which have supplied an output of somewhat less than 3,000,000 tons. The confines of the area have not been marked out as yet, but the development work indicates the existence of at least 1500 acres of unmined ground, with a probable supply of not less than 25,000,000 tons. The reserves may be much larger. They assure a long life for the industry at the recent rate of production.

East of Monroe county the Camillus beds have been little explored for gypsum, and activities in the past have been practically restricted to the outcrop where natural ledges may be worked by quarry methods. Only one or two localities have been tested with the drill to show the underground conditions. At Victor, Ontario county, a deposit about 100 feet below the surface was found by the drill, and is now in process of development by Victor Plaster, Inc. The

bed is about six feet thick. Farther east the seams thicken measurably, but there is a diminution in the content of gypsum, so that most of the rock hitherto shipped from that section has averaged between 65 and 75 per cent hydrated calcium sulphate. Of such grade of rock there are undoubtedly very large supplies. In Cayuga county, near Union Springs, the old quarries show a seam from 30 to 40 feet thick. In Onondaga county, around Lyndon and Fayetteville, the beds are even stronger, attaining a thickness of 50 to 60 feet, the maximum for the entire belt. Substantial beds occur as far east as Oneida, Madison county.

Considered in their entirety the resources are undoubtedly very large, although not subject to anything like an accurate estimate from present information. If mining were carried on without particular reference to the grade of rock, they would undoubtedly suffice for an indefinitely long period of future production, even at the accelerated rate prevailing in recent years. But another aspect of the matter is had if attention is directed to the known supplies of high-grade gypsum and to the steadily increasing drain upon these resources. One-fifth at least of the Erie-Genesee county acreage of the main seam has already been exhausted. The output has increased eightfold in 20 years and more than doubled in the past five years. At the indicated rate the present resources would last for not over 20 or 25 years, even with allowance for a certain slowing up in the annual increase in production which is likely to be manifested in the future.

Eventually, the resources of lower-grade material must come into wider use. Previous experience has demonstrated the technical feasibility of mixing the leaner rock with high-grade material for calcined plasters, and this practice may be resorted to in time as a means of conserving the limited supplies of the latter. It would appear practicable also to replace the shipments of cement rock from the western field by the more cheaply obtainable gypsum from the eastern field.

### Erie County Districts

The part of the gypsum belt which lies in Erie county has been developed within the last quarter of a century. Active mining in fact did not begin until about 1906, although the deposits were discovered and explored a few years earlier. The American Gypsum Co., now a part of the Universal Gypsum and Lime Co., and the Akron Gypsum Co., now owned by the Beaver Products Co., were the first enterprises in the field. Their properties lie to the east of

Akron and include most of the mineable area between that village and the Genesee county line; those of the Universal company extend for some distance into that county, where mining is now in progress. Both companies operate in a large way and manufacture a comprehensive assortment of products, including wall plasters, board, tile etc., besides marketing cement rock.

To the west of Akron a new field has been opened within the past five years, which constitutes the largest addition to the resources of high-grade gypsum that has been made for some time. This may be called the Clarence district, as the major part of the acreage lies within that town with Clarence Center at about the midpoint of the area. The total length of the explored section is about 12 miles and the gypsum bed, according to S. E. Sill, who has directed the testing operations, ranges up to 6000 feet wide from the outcrop to the anhydrite zone which latter is encountered at a little over 100 feet vertical depth. The resources of the district within the indicated distance are between 35,000,000 and 40,000,000 tons according to Mr Sill's calculations. The average content of the rock in the fully hydrated phase is well over 90 per cent and runs up to 98 per cent. There is only one seam of the kind which varies from four to five feet thick. A specimen log selected from a number of drill holes is here given:

| | FROM | | TO | |
|---|---|---|---|---|
| | Feet | Inches | Feet | Inches |
| Soil and drift | ...... | ...... | 46 | ...... |
| Limestone | 46 | ...... | 70 | 10 |
| Shaly limestone | 70 | 10 | 71 | 2 |
| Limestone | 71 | 2 | 76 | 6 |
| Gypsum | 76 | 6 | 77 | ...... |
| Limestone | 77 | ...... | 78 | 3 |
| Gypsum, impure | 78 | 3 | 79 | ...... |
| Limestone, inclusive of gypsum | 79 | ...... | 80 | 6 |
| Gypsum, shaly | 80 | 6 | 84 | 8 |
| Gypsum | 84 | 8 | 85 | ...... |
| Limestone | 85 | ...... | 88 | 4 |
| Gypsum | 88 | 4 | 92 | 6 |
| Limestone | 92 | 6 | 93 | ...... |

The main seam is found in this test hole at 88 feet, 4 inches depth and measures 4 feet, 2 inches thick.

Since the opening of this area two enterprises have started mining operations, the Atlas Gypsum Corp., which has developed a property at Clarence Center for the shipment of cement rock, and the National Gypsum Co., with holdings to the west of those of the Atlas Corp.,

on which a large plant has been erected for making calcined plasters and wall board, one of the best examples of a modern gypsum mill. The continuation of the bed to the west of this property is held by the Standard Gypsum Co. East of Clarence Center the acreage is covered by various holdings on which no immediate development seems to be in prospect.

### Genesee County Field

The Akron district mentioned under Erie county extends to the Genesee county line, near which is located the plant of the Universal Gypsum & Lime Co., whose mining properties lie in both counties. The next mining developments are encountered near South Alabama, four miles west of Oakfield, where the Phoenix Gypsum Co. is engaged in the shipping of cement rock. Its property was opened in 1920. The Oakfield Gypsum Products Corp. and the Niagara Gypsum Co. operate in the area to the east of South Alabama, the former company having entered upon production five years ago and the Niagara Gypsum Co. about 1908. The Oakfield Gypsum Products Corp. was the first to erect a mill designed for the use of the rotary method of calcination, with which the superintendent, H. W. Olmstead, had experimented previously while operating in the Garbutt district. The Niagara mill, under the supervision of E. P. Kleppinger, was equipped with rotary calciners in 1918, the earliest installation to be placed in continuous operation. This method has since been widely adopted. The United States Gypsum Co. controls the lands eastward of those owned by the companies just named and extending into Oakfield village, which is the present limit of the developed area in Genesee county. The company is the successor in ownership to the original sites of the early calcined plaster mills that were started in the '90's of the past century and is the largest of the gypsum miners and manufacturers in the State.

The basis of the industry in this field is a single continuous seam averaging about four feet thick, known to extend some six miles on the strike and with a general width of somewhat less than a mile. The resources of the indicated area before mining may be put in round figures at 40,000,000 tons. There is still some possibility of enlarging the field by extension to the east of Oakfield and also on the west end in the limits of the Tonawanda Indian Reservation. Such developments may increase the tonnage by a fraction of the amount indicated for the territory already in process of mining. The territory from a short distance east of Oakfield to the Monroe

county line has been prospected at various places without much result in the way of uncovering a workable deposit. It would appear that between the Oakfield and the Garbutt districts there is an interval in which the gypsum occurs only in thin layers of little value for mining.

Perhaps the larger part of the undeveloped acreage in the Oakfield district lies to the southwest of South Alabama, between the lands of the Phoenix Gypsum Co. and the Tonawanda Indian Reservation. An area of about one and one-half miles along the strike of the gypsum and beginning one-half mile west of South Alabama was tested a few years ago. The usual bed of about four feet of high-grade rock was traced the whole distance, but the width diminished from about 5000 feet on the eastern border to 500 feet on the west. The anhydrite zone was found at depths between 110 and 125 feet. The following log is taken from one of the deeper tests and will indicate the general character of the upper Camillus succession in this region.

| | FROM | | TO | |
|---|---|---|---|---|
| | Feet | Inches | Feet | Inches |
| Earth | ...... | ...... | 35 | 8 |
| Limestone | 35 | 8 | 43 | 3 |
| Mud seam | 43 | 3 | 44 | 7 |
| Limestone, broken | 44 | 7 | 57 | 6 |
| Limestone with gypsum | 57 | 6 | 59 | 8 |
| Limestone | 59 | 8 | 68 | 4 |
| Limestone with gypsum | 68 | 4 | 70 | ...... |
| Limestone | 70 | ...... | 73 | 10 |
| Gypsum, shaly | 73 | 10 | 78 | 5 |
| Limestone with gypsum | 78 | 5 | 81 | 9 |
| Gypsum, main seam | 81 | 9 | 85 | 11 |
| Limestone | 85 | 11 | 91 | 6 |
| Gypsum, shaly | 91 | 6 | 96 | 6 |
| Limestone | 96 | 6 | 97 | 8 |
| Gypsum, gray | 97 | 8 | 98 | 10 |
| Gypsum, shaly | 98 | 10 | 101 | 2 |

Analysis of the core of the main bed, 4 feet, 2 inches thick, showed 93 per cent hydrated calcium sulphate.

Throughout Erie and Genesee counties the gypsum follows closely the outlines of the Onondaga ledge, the most prominent topographic feature of the region. The Camillus strata usually appear at the foot of the ledge, of which the lower part consists of Bertie waterlimes, and extend northward below the nearly flat plain that stretches toward Lake Ontario. The outcrop of the beds is nearly everywhere concealed by a heavy mantle of glacial sands and gravel.

## Monroe County

The Camillus strata, with locally developed beds of gypsum, extend east and west across the southern townships. Gypsum occurrences have been noted in the town of Chili, Riga and Pittsford, but the only mines in present operation are in Wheatland, in the southwestern corner of the county, where Allen's creek has eroded a channel into the upper Camillus and brought to light substantial deposits. The southerly and northerly continuations of the gypsum seams underlie probably an area of several square miles, although their limits are as yet undefined. Accessibility for working and favorable shipping facilities have aided their development, so that Monroe ranks next to Genesee and Erie counties in production of rock gypsum. One of the first mills for grinding land plaster was built at Garbutt about the year 1812, on the site now occupied by the plant of the Empire Gypsum Co. Mining has been in progress since that time.

The developed area in the Wheatland district includes about two miles on the trend of the beds, with Wheatland Center and Garbutt marking the approximate limits. The mining ground lies mostly to the south of Allen's creek, but the hills on the north side contain the surface outcrop of the beds and have been explored by open workings. Two gypsum seams, each about six feet thick and separated by from six to 12 feet of limestone, are present in parts of the area at least; they show a somewhat darker material than the Oakfield gypsum, averaging about 75 per cent hydrated sulphate, with portions that analyze over 80 per cent. The calcined products develop good strength and working qualities, and are employed for wall plasters and for casting into block and tile, with excellent results. Board has also been made in the district.

The Ebsary Gypsum Co., Inc., operates at Wheatland Center, where it has erected a modern plant and reopened the mines formerly worked by the Consolidated Wheatland Plaster Co. The gypsum body is supposed to represent the second or lower seam, which is reached by an incline from the crusher building. The vertical distance to the bed is only 35 feet. Besides wall plasters the company manufactures gypsum wall board, cast tile and block which are distributed in the eastern markets, mainly in the New York district. To the east of this plant and near Garbutt are the mines of the Lycoming Calcining Co. and the Empire Gypsum Co., which explore the upper of the two seams through sidehill adits driven southward from Allen's creek. The ground to the south rises very

gradually for the first mile or two, so that beds may be followed for unusually long distances before anhydrite begins to appear.

The actual limits of the Wheatland gypsum area have not been outlined by drilling. There is some evidence that the beds are cut out between Wheatland Center and Mumford by a concealed rock channel, and exploration between Mumford and the Genesee county line has so far failed to disclose any similar deposits. Little has been done to test the Camillus strata east of Garbutt in the direction of Scottsville. The known and probable resources within the developed area, however, are very large, since the two seams will yield over 30,000 tons to the acre and they apparently cover an area of not less than two square miles. There is also a stretch of unprospected ground in the towns of Mendon and Rush that seems favorable for the occurrence of gypsum. The line of the Camillus outcrop about connects Rush village with Mendon and Victor.

### Livingston County

The northern limits of this county do not reach to the outcrop of the gypsum beds, but their continuations on the dip have been encountered in test holes at depths of 100 feet or more. Thus in the town of Caledonia, south of the Wheatland district of Monroe county, the two seams have been penetrated at 160 feet in a gas well, and in the vicinity of Avon, some 15 miles from the outcrop, anhydrite was found in the approximate stratigraphic position of the Wheatland gypsum at around 800 feet depth. Whatever resources occur in the county have no potential importance so long as supplies can be obtained nearer the surface.

### Ontario County

The Camillus belt extends east and west through the northern townships of Victor, Farmington, Manchester and Phelps, with a width of two or three miles near the Monroe county line, which gradually expands to five miles or more on the eastern border where it enters Seneca county. There are two horizons in which gypsum occurs, one being near the top of the Camillus, just under the Bertie, and the other about 120 feet lower in the series. The county has supplied considerable quantities of agricultural rock from open quarries situated near the villages of Victor and Phelps and from workings along Canandaigua outlet between Manchester and Phelps. Apparently the upper bed or beds are represented in these places. With the decline in the use of agricultural plaster, operations

gradually dwindled until the last of the quarries went out of business about 1908.

Exploration of the lower gypsum seam has been confined to the vicinity of Victor, where considerable drilling was done some 20 years ago. One of the areas explored is on the flats along Ganargua creek east of the village; several test holes put down by C. L. Tuttle of Rochester showed a six-foot seam of gypsum at a depth of a little more than 100 feet below the surface. The neighboring property has recently been acquired by Victor Plaster, Inc., and steps taken toward its development for production of cement rock and calcined plasters. A shaft has been put down in a central location and plans are in preparation for the erection of the necessary buildings and equipment to put the property on a production basis. The gypsum penetrated by the shaft at 104 feet depth is a gray, finely textured rock of commercial grade. The rock removed from shaft opening indicates the presence of several smaller seams above the main bed.

Elsewhere in Ontario county no systematic tests have been made and little is known as to the quality and extent of the resources.

## Seneca County

The gypsum series underlies parts of the towns of Tyre and Junius, but they are concealed by glacial materials over most of the area. At one time quarries were operated near Black brook west of Nichols Corners and along Seneca river. The openings are now caved, and there are no records indicative of the nature of the deposits except the mention by Luther (Geology of the Geneva-Ovid Quadrangles, Mus. Bul. 128) of the occurrence of 25 feet of gypseous shale, parts of which are stated to be sufficiently pure to have some economic value. The gypseous shale is probably weathered limestone with gypsum seams.

## Wayne County

This county is outside the limits of the main Camillus belt, although the lowermost strata have been uncovered in places in wells and excavations, as at Clyde, Lyons and Palmyra on the lines of the New York Central railroad. It is doubtful if the horizon of the larger gypsum beds is represented over any extensive area.

## Cayuga County

This county has been one of the more important sources of gypsum rock in the eastern district. The Camillus beds cross under Cayuga

lake from Seneca county and appear in outcrop on the shore north of Union Springs. They continue north and east to a point north of Auburn and then continue mainly eastward toward Skaneateles Falls, where they pass into Onondaga county. The vicinity of Union Springs affords the only good exposures of gypsum; for the rest of the distance the Camillus beds are mostly buried below glacial deposits which are particularly heavy in this region.

Gypsum has been quarried along the lakeside from two to three miles north of Union Springs, from which area perhaps 500,000 tons of cement rock and agricultural plaster have been shipped, also at Cross Roads on the Lehigh Valley railroad east of the lake, and again at Cayuga near the north end of the lake. The deposits are substantial, ranging up to 40 feet thick and exceeded in that respect only by the beds of Onondaga county.

The rock falls into the medium-grade class with perhaps 70 per cent hydrated calcium sulphate, although when sorted it may carry as much as 80 per cent. The workings so far have been open cuts, in which the gypsum was found directly under the soil and earth, where it has been subject to some disintegration and partial removal by surface agencies. The occurrences so situated are generally outliers of the regular beds inclosed by the Camillus, and are found in low mounds or dome-shaped areas which afford only limited supplies. The more extensive beds that probably exist to the south have not been opened.

The Union Springs locality is one of the more advantageous situations for gypsum production in the eastern counties, as it provides both rail and water shipment, the outlet of the lakes having connection with the Barge canal system. The conditions are favorable to the occurrence of large supplies of a grade about as indicated for the exposed deposits. Drilling is necessary to prove the actual extent of the deposits, and without such information it is impossible to offer anything more than a guess as to the supplies.

## Onondaga County

The Camillus beds attain their maximum development on the outcrop within this county and hold the largest seams of gypsum that have been anywhere uncovered in the State. They occupy a belt that extends from the Cayuga to the Madison county line, crossing on a line a little south of Syracuse and with many up-stream deflections where the rivers intersect the belt in their northward course. Many localities occur near Martisco along the Auburn

branch of the New York Central lines, south of Camillus, at Jamesville, Lyndon, Fayetteville and between Fayetteville and Chittenango.

The more important of the workings, so far as past production is concerned, are those near Jamesville and Lyndon. They are located on the face of bluffs that bring the gypsum seam to outcrop from under a capping of hard limestone. The seam is 30 feet thick in the outcrop north of Jamesville where it has been worked for cement rock and land plaster. The seam is made up of several layers which show variation in gypsum content but which do not average above 65 or 70 per cent in the quarry run. About all the gypsum available for open cut work has been removed, so that in the future, drifting under cover must be resorted to. Openings of this kind became necessary, in fact, some years ago. The Lyndon quarries are on an isolated knob that stands out from the main ledge, where the overburden is thinner, but here, too, open quarrying has reached nearly the practical limits for handling the cover of limestone and dirt. The exposed faces show up to 60 feet of gypsum in several layers. The latter are brown, gray or drab in color, according to the degree of weathering and contained impurities. The rock has been used to some extent for calcination for wall plasters. At one time a calcining plant was operated on gypsum obtained from the Lyndon quarries. Shipments of crude rock were also made by canal to New York, where it was mixed with Nova Scotia material for the manufacture of calcined products. The main item of production, however, has been agricultural plaster.

In the town of Eldridge between Martisco and Halfway is an exposure that contains gypsum of a better quality than the average. About 15 feet is exposed in that region, of which the upper layer of four feet has a light gray to white color.

Knowledge of the resources of Onondaga county is limited entirely to observations made on the outcrop which are too sporadic and incomplete to afford a basis for estimation. It is safe to say, however, that they run into millions of tons. The conditions admit of low-cost production, and the only drawback to industry is that incident to marketing material of the indicated grades.

## Madison County

The eastern limit of the Camillus with substantial gypsum seams is reached in Madison county in the town of Stockbridge near the Oneida county line. From there west to the Onondaga county border gypsum has been quarried at intervals on a limited basis for

agricultural uses. The showings in the quarries, now abandoned, indicate a low-grade material, consisting mainly of intermixed gypsum and shaly limestone, the whole mass carrying perhaps 60 per cent or less of the sulphate. Selected samples may run considerably higher. The quarries are situated on outlying hills and spurs of the high ridges formed by the covering limestones where conditions are most favorable for open-cut work. No exploration of the deeper beds has been carried out. In view of the thicker and better grades of rock obtainable in Onondaga and Cayuga counties, there is little encouragement for reopening the workings except for possible local demands of land plaster.

### Prospecting and Mining Methods

The hazards of mining are present in gypsum production so that rather thorough investigation, both on the surface and underground, is a necessary step to the formulation of plans for new ventures. The fact that the deposits have the form of beds with considerable lateral extent is an aid to their discovery and delimitation, but nevertheless there are many uncertainties about their occurrence which can only be removed by careful geological study supplemented by tests with the drill. Experience has shown that deposits of workable size and grade are found only at intervals along the outcrop. Their presence may or may not be indicated by surface exposures. In the western area no natural exposures are encountered from the Niagara river to the vicinity of Garbutt, and again to the east of Garbutt there are no showings of gypsum for another long interval.

A second matter that requires investigation in each area relates to the transition zone between gypsum and anhydrite. Experience in the western field indicates a close relation between depth and the change from the hydrous to the anhydrous form of calcium sulphate, but the observations obtained in one area may not necessarily hold valid in another district. It can only be anticipated that anhydrite will be found below the gypsum at some, probably not very considerable, depth.

Again, it has to be borne in mind that the glacial sands, gravels and clays which mantle the deposits nearly everywhere may mask hidden rock cuts and channels that interrupt the continuity of the beds.

For testing operations the core drill is best adapted and has been employed in most of the recent work. In as much as the range of exploration does not extend as a rule below 100 or 150 feet depth

a light portable rig is well suited for the purpose. The diameter of the drill bit should be not less than about two inches to insure good core recovery, for the gypsum is soft and fragile with a tendency to break down readily under pressure. A well rig may be employed to put down the tests through the overlying earth and hard limestones, after which the core should be cut by a diamond bit.

Underground mining is practised by all the producing enterprises at present. With the discontinuance of activity in central New York, quarry operations are no longer carried on. The usual method of opening the seams is to sink a vertical shaft to the required depth, which in most places varies between 40 and 80 feet. Under some conditions preference may be given to an inclined shaft or slope. In the Garbutt district the seams may be entered from a sidehill opening extended down the dip. The modern shaft installations have steel head-frames and are usually divided into four compartments of which two are used for hoisting, one for ladder-way and one for ventilation. The selection of a shaft site is one of the more important steps in the process of mine development, for upon it hinges to a great extent the convenience and economy of subsequent operations.

In general the underground layout of a gypsum mine resembles the plan adopted for many flat coal seams. The bed is worked by a room-and-pillar system, in which regular rooms or panels are set off with a width of about 20 feet and a pillar left for roof support, so that 75 per cent or more of the gypsum is removed in the first operation. After the area has been worked in this way, some or all of the gypsum left in the pillars may be recovered. Little timber is used except as props to sustain a weak roof. The drilling is performed by a special type of drill which consists of an auger bit carried on a long shaft and turned by an independent electric motor mounted on the drill column. The soft gypsum is penetrated very rapidly. Anhydrite or limestone, if encountered, checks the speed to a fraction of the normal rate. Undercutting machines have been tried but do not seem to give results comparable to their service in bituminous coal. Blasting of the rock requires only a low-grade explosive; dynamite of about 20–25 per cent strength is usually employed.

Mining costs in New York are higher than for most districts in the central and western States and much higher than those prevailing in the Maritime Provinces of Canada, with which the local product competes in the market. The costs have shown an upward trend for the past 25 years, reaching an absolute maximum in 1920 and 1921.

There has been some abatement since then. The New York mines are handicapped by the relatively thin seams which are worked to secure the desirable high-grade rock and by the considerable amount of water that has to be pumped from the workings. The latter is a variable factor, more important in some mines than in others. It is probable that many of the western mines have an advantage of $0.50 or $0.75 a ton over the New York producers, while the differential in favor of Nova Scotian shippers may be as much as $1 a ton. The latter have become important competitors in the eastern markets within the last few years and under favorable shipping conditions, with continuance of present tariff schedules, are likely to increase their exports very largely in the immediate future.

## Milling Practice

The technology of gypsum has undergone many changes and improvements in the past few years. To describe the recent developments in mill practice would require much more space than is available in this article, and only a few of the more important features will be indicated. It may be stated in general that the recent improvements have tended toward a greater diversity of products than was heretofore obtainable, as well as to increase the efficiency of the milling operations.

The production of half hydrate, which is the basis of the majority of gypsum materials used in the building trades, consists essentially of two operations: (1) reduction of gypsum to fine size by crushing and grinding, and (2) calcination by which three-fourths of the water content is expelled, leaving calcium sulphate with one-half molecule of water, or half hydrate. In the early practice the calcination process was performed in upright retorts or kettles. In 1917 end-fired rotary kilns similar to those used in portland cement manufacture were introduced in one of the western New York plants and have since been adopted by many of the companies, so that the larger part of the calcining capacity is now represented by such kilns. The kilns are five to eight feet in diameter and 60 to 120 feet long, with rated capacities of from 10 to 30 tons an hour. They are of course continuous in operation and require less fuel for heat and power to the ton of product than the kettle. With their use the rock undergoes its final reduction after calcination, whereas with the kettle it is usually dried and pulverized before calcination.

Crushing operations have been much simplified by the use of modern types of machines like hammer mills which are particularly

suitable for soft gypsum. They are built in sizes that take the run-of-mine rock and reduce to about one-inch mesh, suitable for kiln calcination, in one stage. The combination of fine grinding with air flotation insures a greater uniformity in the pulverized material for the kettle process.

Whether calcination is carried out in kettles or rotary kilns, the product that is to be turned into wall plasters is ordinarily finished by grinding in a tube mill, which operation has been found to increase its plasticity. Some plants combine both kettle and rotary kiln methods; the former seems to be better adapted for making calcined gypsum to be used in casting and molding plasters which are not usually reground, and the kiln for making wall plasters that are greatly improved by this final treatment.

One of the newer mill products that are made in the New York plants is calcined gypsum for concrete, which is a special grade treated to give density in the poured aggregate. It is used for walls of small buildings, for nonbearing partitions, and in floors and ceilings of steel-frame structures. It sets more quickly than cement and is somewhat lighter for the same bulk. Rock lath is an improved form of plaster board. Gypsum board is now made for the sheathing of buildings. The outside surface is water-proofed, and the material which is usually one-half inch thick is equivalent to 7/8-inch lumber in strength and has the advantage of being noncombustible. Acoustical plaster is a gypsum plaster that is absorbent of sound waves, used in auditoriums and theatres. A porous, very light gypsum for heat insulation is made by adding some chemical that evolves carbon dioxide during the setting process, thus giving the product a spongy texture. The better known uses of gypsum in wall plasters, wall board, plaster board, tile and block still maintain their importance and represent the more substantial items of consumption.

### Production of gypsum in New York in 1925

| MATERIAL | SHORT TONS | VALUE |
|---|---|---|
| Total mine output | 1 730 254 | .......... |
| Sold crude: | | |
| To portland cement mills | 350 806 | $1 003 128 |
| As agricultural gypsum | 1 659 | 8 467 |
| Other uses, paint etc | 1 929 | 5 808 |
| Sold calcined: | | |
| Stucco | 185 427 | 1 058 213 |
| Neat plaster | 591 383 | 4 755 138 |
| Sanded plaster | 36 717 | 337 929 |
| Plaster of Paris, molding etc | 27 176 | 286 151 |
| Plaster board | 42 154 | 926 895 |
| Wall board | 188 960 | 6 568 527 |
| Partition and roof tile | 107 243 | 1 165 191 |
| Special tile, insulating, fireproofing etc | 6 082 | 104 459 |
| Total | .......... | $16 219 906 |

### Production of gypsum in New York in 1926

| MATERIALS | SHORT TONS | VALUE |
|---|---|---|
| Total mine output | 1 723 460 | .......... |
| Sold crude: | | |
| To portland cement mills | 324 864 | $891 680 |
| As agricultural gypsum | 927 | 4 581 |
| Other uses, paint etc | 2 295 | 8 834 |
| Sold calcined: | | |
| Stucco | 134 841 | 880 152 |
| Neat plaster | 633 656 | 4 899 188 |
| Sanded plaster | 54 204 | 351 797 |
| Plaster board | 54 492 | 1 030 574 |
| Wall board | 190 245 | 6 610 455 |
| Partition tile | 132 486 | 1 557 291 |
| Roof tile and special tile or blocks | 10 057 | 125 334 |
| Insulating purposes and other purposes | 3 885 | 87 508 |
| Plaster of Paris, molding etc. and dental plaster | 32 596 | 347 195 |
| Total | .......... | $16 794 589 |

## IRON ORE

The recent record of iron mining in New York State runs counter to the trend of most of the mineral industries. The depression that came with the close of the war has not fully lifted in respect to the eastern ore markets, and prices are still at an unsatisfactory level for the mines situated within the tributary region. Many of these have been closed and the others for the most part have produced at a rate much below capacity. The present yearly output of ore in the State is less than one-half of the former figures.

Increased competition from foreign ores is one of the factors responsible for the unsettled market. The imports of iron ore have grown from 315,768 long tons in 1921 to 2,555,441 long tons in 1926, practically all entered at north Atlantic ports for use in eastern furnaces which are the natural outlets for the local mines. The shipments are made by various countries, including Cuba and Chile where the mines are controlled by steel works in this country, and by Sweden, Spain, Algiers and Tunis in the list of independent shippers. Low ocean freights are requisite to imports from the latter countries. Under favorable conditions, like those recently in effect, foreign ores can be landed at a cost under that at which local ores can be mined and shipped a few hundred miles by rail to the furnaces.

The production of iron ore in New York for the past ten years is shown in the following table. In the period the list of active mines has included only a few of the Adirondack properties and one or two in southeastern New York, all of which produce magnetite in the form of lump ore and concentrates. The small output of hematite is from the Clinton mines in central New York. The figures for 1917 include a small output of limonite from southeastern New York, the last of such shipments reported in the State.

**Production of iron ore in New York State since 1917**

| YEAR | MAGNETITE LONG TONS | HEMATITE LONG TONS | TOTAL LONG TONS | VALUE |
|---|---|---|---|---|
| 1917 | 1 313 708 | 40 816 | [a] 1 356 011 | $7 381 333 |
| 1918 | 859 188 | 40 782 | 899 970 | 5 802 870 |
| 1919 | 666 176 | 44 150 | 710 326 | 4 037 225 |
| 1920 | 950 537 | 22 372 | 972 909 | 6 321 999 |
| 1921 | 174 368 | 2 445 | 176 813 | 961 477 |
| 1922 | 191 195 | 14 769 | 205 964 | 1 163 040 |
| 1923 | 722 096 | 12 849 | 734 945 | 3 320 004 |
| 1924 | 303 386 | 12 966 | 316 352 | 1 512 571 |
| 1925 | 413 517 | 15 731 | 429 248 | 2 074 426 |
| 1926 | b | b | 673 103 | 3 103 312 |

*a* Includes 1487 tons of limonite.
*b* Figures not segregated.

The production of 176,813 gross tons in 1921 was the smallest recorded since statistics have been collected from the mines. Under normal conditions the shipments might be expected to run well over a million tons. Later figures indicate a partial recovery from the severe slump of that year, but the output is still on a much reduced scale.

### Adirondack Mines

In the Port Henry district the active mine operators have been the Port Henry Iron Ore Co. and Witherbee, Sherman & Co., with properties at Mineville, six miles northwest of Port Henry, the shipping point.

The Port Henry Iron Ore Co. extracted ore from the Old Bed deposits which carry magnetite with about 60 per cent iron and 1.5 per cent phosphorus. The output was shipped in lump form for furnace use.

Witherbee, Sherman & Co. produced ore from its Old Bed, Harmony and Barton Hill properties. The Old Bed high phosphorus magnetite came from the lower seam which underlies the main body worked in earlier years. The output was milled to reduce the phosphorus content and as shipped contained about 64 per cent iron. The Harmony mine to the southwest of the Old Bed group yielded concentrating ore, with medium phosphorus content and about 63 per cent iron in the mill product. The Barton Hill or New Bed magnetite was of low phosphorus grade and the mill run carried about 65 per cent iron. All the mine operations were centered about these properties which occupy a relatively small area and can be most advantageously worked, whereas the outlying deposits were idle. The company has a large modern furnace at Port Henry where a part of the output is smelted into pig iron.

At Lyon Mountain in the northern Adirondacks, the Chateaugay Ore and Iron Co. maintained steady operations. The deposits yield a special grade of ore, notably low in phosphorus, that has little competition in the markets and is mainly used by the company for manufacture of a superior grade of iron. The phosphorus content of this iron is less than 0.02 per cent. The mines are worked through an inclined shaft which has been put down in the past few years as a main opening to take the place of several smaller inclines. The four-compartment shaft follows the general dip of the ore at an angle of 63° and is bottomed at 1685 feet. Levels are opened at intervals along the strike of the ore body. The ore is brought from the stopes to the shaft by cars drawn by storage battery locomotives and is

loaded into the skips through chutes. The crude magnetite is crushed and separated, the concentrates carrying 62.5 per cent metallic iron. Before shipment the concentrates are sintered. The company smelts the output in a furnace at Standish near Lyon Mountain. The pig iron is sold to makers of high-grade steels, but the company plans to convert a part into steel castings and ingots in its own plant, for which the necessary equipment will be installed.

The Benson Mines Co., which formerly operated the properties at Benson Mines, St Lawrence county, has made no production in recent years.

In the central Adirondacks the large bodies of magnetite at Lake Sanford remain undeveloped. These deposits carry considerable titanium in the form of ilmenite which is mixed with the magnetite. Although such ores are usually considered difficult to treat in a furnace, it would appear from experimental tests that the percentage of titanium can be reduced by mill treatment to a point where it could be smelted readily in mixtures with other ores. The resources of the district are probably the greatest in the Adirondack region, but are somewhat remote from the railroad.

### Southeastern New York

The region along the Hudson river has produced important quantities of ore. The shipments have included siderite from the district near Hudson, limonite ores from a number of workings in Columbia and Dutchess counties, and magnetites from the Precambrian area of Orange and Putnam counties. The deposits of this section were the first to be worked on a commercial scale and for a century or more they supported an active industry. Of late years the Forest of Dean mine and the Sterling mine, both in Orange county, have been the only shippers, and at present the sole operative mine is the Forest of Dean, worked by the Fort Montgomery Iron Corp. The ore is magnetite and carries about 60 per cent iron. It is shipped crude.

### Clinton Hematite District

The present operations in the Clinton hematite belt are restricted to the production of ore for manufacture of metallic paint. The shipments to outside furnaces were discontinued with the close of the war. The largest producers of paint material have been the mines at Clinton, Oneida county, including those of the Clinton Metallic Paint Co. and those formerly worked by C. A. Borst. In Wayne county the Fruitland Iron Ore Co., at Fruitland, and Stanley Dog-

gett, Inc., at Sterling Station, have shipped some ore for similar purposes.

## MARL

Considerable interest in a possible more extended use for the marl deposits of the State is manifested from time to time. There is scarcely a county in the State where marl deposits do not occur. In some sections individual areas have an extent of several thousand acres. In thickness the marl beds range up to 30 feet. The thickness of most of the deposits probably will not on the average exceed five to seven feet. Large deposits are known, however, with a thickness of as much as 14 feet.

The deposits of marl are found mainly in swamp and shallow lake areas. In origin marl represents either an accumulation of small organic shells, or a deposit of calcareous material derived from the lime held in solution by carbon dioxide in the waters of tributary streams. The lime brought in by streams is dissolved from the limestones and soils over which the stream flows. The deposition of the lime is effected by evaporation of the water and the escape of the solvent carbon dioxide, both processes being much facilitated by an increasing temperature of the water. In some cases deposition of carbonate matter may take place along streams and at springs. Deposits formed at such places are known as calcareous tufa or travertine and often contain plant remains. Such material is of a more compact nature than marl and in some localities firm enough to be quarried for building stone.

In composition marls are essentially unconsolidated limestones. The chief difference between marls and the hard compact limestones is physical rather than chemical. Chemically marls often contain well above 90 per cent of lime carbonate. Marl may be used in the place of hard limestone in the manufacture of portland cement. Formerly a number of cement plants in the State used marl, but none of these are in operation at present. The chief drawback to the use of marl is the large water content when freshly excavated. The cost of handling this dead weight and the drying of the marl before it is ready for use were important factors leading to the abandonment of cement plants in which marl was employed. Although marl makes a good lime, its manufacture requires the briquetting of the marl before it enters the kiln. This, in addition to the removal of the water content, makes production costs relatively high, and there is no advantage in its use in a region where limestone is available.

One of the commercially practical uses for marl is in agriculture for improvement of soils, but even here it finds severe competition from crushed and ground limestone. No marl plant has been in operation in the State since 1924, when the Bone Dry Lime Corp., operating at Cassadaga lake, Chautauqua county, reported production. The Soilife Humus Co., Inc., of Buffalo, now owns the property formerly controlled by the Bone Dry Lime Corp., and planned to produce marl in 1927.

## MILLSTONES

The production of millstones or burstones is carried on in a small way in the Shawangunk mountain area from the grit which outcrops along the northern edge of the ridge. The industry has been established a long time and for many years enjoyed prosperous conditions through the extensive sale of the product for cereal mills. This market has been gradually curtailed within the past quarter of a century or more by the introduction of the roller mill process for making flour, although some mills still retain burstones for grinding the coarser cereals. At present the quarrying and shaping of the stones gives employment to a small number of men who engage in it during a few months of the year when not otherwise employed. The product is sold chiefly among the small corn mills in the South. Besides millstones, the quarries also turn out disks of stone which are called chasers and are employed in the roll type of crusher, the discs revolving on edge in a circular pan that is sometimes paved with blocks of the same stone. This type of crusher is used more or less in the pulverization of materials like quartz, feldspar, barytes and mineral paints.

### Occurrence of Grit

The Shawangunk grit is a hard, firmly cemented pebbly sandstone of light gray color. The beds range from 50 to 200 feet, thinning progressively toward the northeast. The layers differ in texture, ranging from a medium-grained sandstone or quartzite to a coarse conglomerate in which the individual pebbles reach a diameter of two inches or so. The pebbles consist of milky white quartz such as occurs commonly in veins and are fairly rounded, showing considerable abrasion during the stage of their accumulation and deposition on the shores of the interior sea on which the beds were laid down.

The cementing substance of the grit is white silica which forms a matrix for the grains but does not wholly fill the voids, thus producing

the bur or cutting surface characteristic of the millstones. The grit is nearly pure quartz and has found application in years past for glass manufacture.

Shawangunk mountain extends from the vicinity of High Falls near Kingston southwest into New Jersey and Pennsylvania and is capped by the grit beds which overlie the Hudson River shales, the whole dipping steeply to the northwest. Material suited to millstone manufacture occurs here and there along the slope of the ridge, in the section between Kerhonkson and High Falls. Some of the localities where extensive quarry operations have been carried on are Kyserike, St Josen, Granite and Kerhonkson. In addition New Paltz and Kingston have been identified with the industry as shipping centers.

## Quarry Methods

The quarry operations are simple and require little equipment, as the amount of stone handled is relatively small. The layer or layers of desirable quality are uncovered by stripping of the overlying soil and rock, and then lifted out by bars and wedges, perhaps assisted by light charges of powder to loosen them from the bed. Blasting, however, is avoided as much as possible lest the stone be weakened. The size of the block is determined by the spacing of the natural joint planes. The block when removed from the bed is roughly squared up and then worked into a disc with the aid of hand hammer and point. The last operation is to drill the center hole or eye. This is usually done by starting a hole in the center of one of the sides and drilling half way, then reversing and cutting a second hole on the opposite face to meet the first. The round eye thus formed may be squared up. The dressing or grooving of millstones is not done at the quarry. Millstones are sold in pairs.

## Production

Considerable difficulty is encountered in obtaining information about the production of millstones. Values, of course, are dependent upon the quality and size of the stones and the quarry prices range all the way from $2.50 to $3 for the smallest size, an 18-inch stone, to $75 or more for an 84-inch stone, which is about the maximum size that is used. The quarrymen may sell the whole or part of their year's product to local middlemen who sometimes work quarries of their own. In the last decade the average production has been less than $20,000, although in earlier years it often exceeded

$100,000. The statistics herewith include the output of chasers as well as millstones:

**Production of Millstones since 1919**

| YEAR | VALUE |
|---|---|
| 1919 | $10 155 |
| 1920 | 13 331 |
| 1921 | 14 672 |
| 1922 | 17 025 |
| 1923 | 10 344 |
| 1924 | 18 215 |
| 1925 | 14 063 |
| 1926 | 23 629 |

## MINERAL WATERS

More than 200 springs in the State have been classed as mineral on the basis of their content of dissolved mineral substances. As a matter of fact all spring waters contain some foreign ingredients, but the proportions are usually so small as to exercise little or no influence upon their potable qualities. Mineral springs, however, carry notable proportions of solids, free acids or in some instances gaseous constituents that distinguish them from the ordinary class of waters and may give them special value for medicinal uses.

Altogether the mineral springs make a considerable contribution to the wealth of the State, although their precise importance in that respect is difficult to estimate. The bottling and distribution of the waters represents a direct source of income for which figures are obtainable without much difficulty. But the incidental benefits derived from the development of the spring localities into places of resort for tourists and health seekers who consume large quantities of the waters on the ground, are beyond estimation and altogether they represent no doubt the largest contribution. Many thousands of visitors are thus attracted to resorts like Saratoga Springs, Ballston Spa, Richfield Springs and Sharon Springs, to mention some of the more popular ones.

An important business has grown up in late years in the distribution of spring waters for drinking purposes among the larger towns and cities. They are not mineralized to any extent, and their employment depends upon their hygienic quality as pure uncontaminated waters, in which respect they are preferable perhaps to the local

supplies. They are distributed in large bottles or carboys. Their value in general may be said to depend upon the provisions made at the spring localities to keep the sources free from surface contamination and the care exercised in providing sanitary conditions for bottling and distribution.

## Character of the Mineral Waters

The principal solid ingredients of the mineral waters of the State are compounds of sodium, potassium, calcium and magnesium, that is, the alkalis and alkaline earths. These so-called bases are compounded with chlorine and carbon dioxide, as illustrated by the waters of Saratoga Springs and Ballston Spa, or they may be united with sulphuric acid chiefly, which is the condition at Sharon Springs, Richfield Springs and most of the localities in the interior of the State.

The springs of Saratoga county contain free carbon dioxide, some holding large quantities of the gas. They are unique in this respect among the springs in the eastern part of the country. As much as five or six volumes are held by some springs, the gas being so abundant that its collection was at one time an industry of considerable importance, the sales exceeding in value that of the mineral waters in the district. The underground reservoirs of the gas and water are found in the Trenton limestone close to fault zones that may conduct the gas from deep sources. The percentage of solid ingredients varies from less than 100 to over 500 grains to the gallon. The waters are used for table and medicinal purposes and for curative baths.

At Richfield Springs the mineral ingredients are combinations of the alkali and alkaline earths with sulphuric acid, together with smaller amounts of chlorine, carbon dioxide and sulphuretted hydrogen. The waters issue from glacial drift, apparently rising from below along the contact of the Onondaga limestone with Marcellus shales. They are mainly employed in medicinal baths. Sharon Springs is situated to the east of Richfield Springs and near the contact of the Ordovician and Silurian strata. Clifton Springs, Ontario county, and Massena Springs, St Lawrence county, are localities for sulphuretted waters. Near South Byron, Genesee county, is a sulphuric acid spring which contains free acid as well as sulphates of iron, calcium and magnesium. Waters highly charged with calcium chloride are encountered in some of the deep wells drilled within the area of the rock salt deposits of central and western New York. They have been employed for medicinal baths.

The Lebanon spring, Columbia county, is the single representation of thermal waters in the State. It has a temperature of 75° F. independent of seasonal variations and contains carbon dioxide and nitrogen in important quantities.

**Production of Mineral Water in New York Since 1917**

| YEAR | PRODUCTION IN GALLONS | VALUE |
|---|---|---|
| 1917 | 7 819 314 | $562 874 |
| 1918 | 5 887 746 | 566 910 |
| 1919 | 6 537 966 | 815 615 |
| 1920 | 5 242 047 | 671 066 |
| 1921 | 5 965 049 | 736 173 |
| 1922 | 6 965 638 | 800 831 |
| 1923 | 6 716 154 | 803 433 |
| 1924 *a* | 6 789 182 | 811 465 |
| 1925 *a* | 7 058 351 | 843 637 |
| 1926 *a* | 7 063 520 | 844 154 |

*a* Value and quantity partly estimated.

## MOLYBDENITE

The mineral molybdenite, which is the principal ore of the rare metal molybdenum now in considerable demand for making certain qualities of steel, is found in several localities in New York State. There has been no effort made toward systematic prospecting of the occurrences, beyond uncovering parts of them, and in fact until recently the limited inquiry for the ore hardly warranted any preliminary operations for the development of supplies. Of late years, particularly during the war and the subsequent period, the market outlets have broadened considerably. In 1926 an output of 2,285,086 pounds of molybdenite was reported for the United States, most of which came from mines in Colorado and New Mexico. Some of the western deposits are said to be very extensive, sufficient to meet the probable consumptive requirements of the whole country for years to come.

Molybdenite, chemically, is a sulphide of the metal with the formula $MoS_2$. In pure state it contains 60 per cent metal and 40 per cent sulphur. In appearance it closely resembles graphite; it is soft, of lead gray color, and occurs in small flakes or in thicker plates which are cleavable into thin scales. It is so easily mistaken for graphite that no doubt its presence in some places has been overlooked,

especially in the Adirondack region where both minerals are to be found. A ready means of identifying molybdenite is by the color of its streak on glazed porcelain which has a greenish tint as compared with the grayish black of graphite.

The mineral is associated more particularly with igneous rocks as a disseminated constituent of the rocks themselves or in the zone of contact between igneous intrusives and other formations like limestone. Granite is the commoner igneous material to accompany its occurrence. No doubt it is an original constituent of the magma, out of which it has crystallized in the cooling process or has been transported by the accompanying emanation of heated waters and vapors into the bordering zone to form veins and contact deposits.

In the southeastern Highlands region, where metamorphosed, igneous and sedimentary formations prevail, the localities for molybdenite include the following: on Manhattan Island between 43d and 44th streets and First and Third avenues in association with mica schist; West Point, Orange county, in granite gneiss; Constitution Island, (Hudson river off West Point) in gneiss; Warwick, Orange county, in limestone; Tilly Foster mine near Brewster, Putnam county, in serpentine; on the Owens farm, north of Peekskill, near the northern border of Westchester county; and in the northern part of Cortlandt township three miles from Peekskill. Of these localities the one in New York City is no longer accessible. From what has been learned indirectly it is evident that the West Point, Constitution Island and Warwick occurrences have little or no interest except from a collector's standpoint. At the Tilly Foster mine molybdenite occurs sparingly as a contact mineral in metamorphosed limestone and is no longer to be found except in the waste dumps of the former workings.

The most interesting locality of those mentioned is that north of Peekskill, on the Owens farm, later a part of the Stuyvesant Fish estate. The showing of ore lies just south of the Catskill aqueduct on the west side of Sprout brook valley. The rock appears to be of contact nature, formed by the alteration of limestone in vicinity of an igneous intrusion, but neither limestone nor intrusive rock is exposed in the immediate vicinity although they occur in outcrops not very remote from the place. The ledge can be traced for several hundred feet, but the part containing visible particles of molybdenite seems to occupy only a small area. The mineral is disseminated in flakes mostly from one-eight to one-fourth inch in diameter and is present in some samples to the extent of 2 or 3 per cent or more.

A shallow pit has been dug within the richer zone. If any considerable body of ore like that in the ledge could be formed in the vicinity, it would undoubtedly be of commercial importance.

In the Adirondack region the Russell locality, in St Lawrence county, has been known for many years and has yielded many museum samples. A. F. Buddington has supplied the following description of the ocurrence as a result of a visit made in 1917:

The molybdenite is found in a green pyroxene rock which has been prospected in a small way for copper. There are few indications of copper, although the rock carries considerable pyrite in thin lenticular bands. Molybdenite occurs in disseminated flakes and aggregates of flakes, some of which attain a size of an inch or so in diameter and an eighth of an inch thick, but mostly are much smaller. The mineral seems to be rather sporadic, and at best too sparsely represented to justify mining operations. The occurrence belongs to the contact type, as the pyroxene rock is the result of alteration of limestone by granite, being in fact enclosed by a body of granite gneiss that no doubt has been the agency of metamorphism and introduced the metal. The wall rock is traversed by veins of coarse phlogopite-pyroxene material which seems to be free of molybdenite. The property in which the prospect lies is just south of Boyd pond, near Russell, and is owned by Martin Leary.

In the course of field work in the northern part of Lewis county, A. F. Buddington discovered a new molybdenite occurrence, of which he has given the following details:

The locality is on the farm of William J. Aucter, in the town of New Bremen, three-fourths of a mile southeast of Bushes Corners. It is reached most conveniently from Croghan, the terminus of a branch railroad from Lowville. The mineral is distributed through the mass of a granite intrusion, or rather within indefinitely bounded veins of pegmatite that occur in the granite. The latter rock has a gneissic appearance and weathers to a reddish color, but is green to pink on fresh surfaces. It may represent a phase of the green syenite that outcrops to the northwest of the described locality. Altogether four narrow pegmatite bands were noted, each scarcely more than one inch wide, exposed on the face of a sloping ridge for a distance of 25 feet. The flakes are relatively coarse and will average from one-quarter to 1 inch in diameter. Traces of the mineral are found at other points along the same ridge. A hill of coarse red gneiss, one-half of a mile south of Stifts schoolhouse, west of the highway, also shows its presence. The locality is one that deserves more careful investigation and possibly some exploration in the hope of uncovering larger veins of pegmatite than those exposed, which on the whole are fairly rich.

Another Adirondack locality for the mineral is in the town of Bellmont, Franklin county, nearly 2 miles southeast of White Church. C. A. Hartnagel with W. L. Allen of Malone visited the place in 1923 and collected numerous samples illustrative of the general occurrence. Some of the samples show larger crystals than have been found heretofore, and in such relative abundance as to justify some attention to the economic possibilities of this region. The country rock is a rather massive phase of the granite-syenite intrusives, to which Cushing in his work on the northern Adirondacks has given the collective name "Saranac series." In the samples at hand a reddish alkali feldspar is the principal mineral in evidence and its predominance would place the rock at the syenite end of the series, although quartz participates to some extent in the composition. Of dark minerals magnetite and hornblende or pyroxene are sparingly represented. The grain is from coarse to fine, the general run being rather finely textured with occasional streaks of coarse pegmatitic material of like composition. According to Hartnagel, the molybdenite shows a tendency toward concentration in more or less parallel zones or belts that do not appear to be governed by any particular structure or other characteristic of the wall rock. The crystals are embedded directly in the syenite and in such a way as to indicate their primary origin as a constituent of the igneous magma. The larger individuals are fully an inch in diameter, measured across the cleavage surfaces and about half as much at right angles, forming unusually thick plates. A yellowish powdery substance has been deposited on some of the surfaces of the molybdenite and in the minute rock cracks around the borders. The substance may be the oxidized compound of molybdenum known as molybdite, but its exact nature has not been determined.

## Uses

The metal molybdenum is prepared from molybdenite by reduction in an electric furnace when the sulphur goes off as dioxide. The metal is gray in color and resembles steel in general appearance. Its use for alloys is not a new development, but its importance in that connection has notably increased within the past decade, beginning with the war. Steel containing a small percentage of molybdenum is hard, tough and resistant to wear. Extended use has been made of molybdenum steel in the lining of heavy ordnance, in the manufacture of bearings, gears and other steel articles intended for heavy duty.

## NATURAL GAS

The commercial production of natural gas is confined to the region of central and western New York. In the central counties only a few small pools have been discovered. The more important natural gas pools lie in the territory between the Genesee river and Lake Erie, including the counties of Erie, Chautauqua, Cattaraugus and Allegany. This territory also includes the more important oil pools of southwestern New York.

Altogether some 25 gas-producing pools have been discovered. The gas occurs at various geological horizons in the Paleozoic rock series. The lowest formation in which gas has been produced in quantity is the Trenton limestone. Most of the deeper wells drilled in Oswego, Onondaga, Erie and Niagara counties have been bottomed in this formation. The Medina formation, the outcrop of which borders Lake Ontario on the south, has produced some of the largest wells in the State. This formation is the main source of supply of natural gas in Cattaraugus, Chautauqua, Erie, Genesee, Livingston, Monroe, Ontario and Wyoming counties. The Salina beds and the overlying Onondaga limestone have yielded gas in Cattaraugus and Erie counties, while the Marcellus dark shale is a source of gas in Cattaraugus, Erie, Livingston, Ontario and Schuyler counties. In Chautauqua county the shallow gas wells along the shore of Lake Erie are in the Portage formation. In the oil-producing counties of Cattaraugus, Allegany and Steuben, the wells which yield gas along with oil are bottomed in the basal Chemung, while wells in these counties which produce gas alone are bottomed in either the Chemung or the next lower formation, the Portage.

The depth to which drilling is carried to reach the productive gas horizons is extremely variable. This variability is due not only to the difference in surface elevations owing to topography, but arises also from the fact that many hundreds of feet separate some of the different gas-bearing formations. Moreover, all of the rocks comprising the stratigraphic series of western New York have a general southerly dip that averages about 50 feet to the mile. From this it is apparent that in passing toward the south each of the formations will be found at progressively increasing depths. It is therefore important when drilling a well to take into account not only the dip of the rock, but also the elevation of the mouth of the well and the position in the stratigraphic series of the formation it is hoped to reach by drilling. Only by so doing can the approximate thickness

of the rocks to be penetrated by the drill be determined. In depth the gas wells range from less than 100 feet for many of the numerous small producing wells, to more than 4000 feet. The latter depth has been reached in only one or two wells. Most of the wells in the best productive pools have depths ranging from about 1200 to 3000 feet.

The production of natural gas in New York State is an old industry. Natural gas springs were known to exist in the State since early Colonial times and several of them were noted by the French explorers. About 1821 actual drilling operations were undertaken at Fredonia, Chautauqua county, where natural gas springs occur. Although the first attempts were on a small scale and the gas obtained was from shallow wells, there was a sufficient supply to light the village of Fredonia, a spectacle observed by General Lafayette in 1825 while on a visit to the United States.

Production of natural gas in large quantities followed the drilling of the first oil well in Cattaraugus county in 1864, and the large developments of oil territory in Allegany county in 1880. In the early years of the oil industry there was little demand for natural gas and large quantities went to waste. With the finding of natural gas supplies in various sections of western New York and the establishment of local gas pipelines, as well as pipelines from the oil fields of both New York and Pennsylvania, the natural gas industry gradually was placed on a businesslike foundation. Moreover, the constantly increasing demand for natural gas, for both heating and lighting purposes, led to a policy of conservation of the natural gas supplies.

Even after the establishment of gas pipelines the growth of the natural gas industry in the State was not rapid. In 1888 the value of natural gas produced in the State was $332,500. In the 16 years following up to 1904, the value of the annual production remained under one-half million dollars. In 1904 with 744 wells, natural gas production reached 2,399,987 M cubic feet valued at $552,197. In volume of production the peak was reached in 1914 when the output amounted to 8,714,681 M cubic feet. Since that date production during several years showed a marked decline. Increase in production during the past two years may be attributed to additional supplies reported by several companies but particularly to the finding of several large producing wells in the town of Arkwright, Chautauqua county.

In addition to the natural gas supplied by wells within the State, Pennsylvania continues to furnish supplies of natural gas that in

volume exceeds the domestic production. Even with the addition of the Pennsylvania supplies there is not enough to meet requirements and in several localities artificial gas is mixed with the natural gas in order to obtain the volume necessary for local needs.

The 1926 production of natural gas from wells located in the State amounted to 7,027,000 M cubic feet valued at $4,999,000. This is the largest value ever recorded and the largest volume since 1920. On account of increasing expenses for drilling new wells, as the present fields become exhausted, it is to be expected the cost of natural gas will continue to increase. The extent of the areas already tested naturally limits the territory where it is possible to find new supplies. The cost of drilling in new territory is necessarily large on account of the large number of dry holes incident to prospecting. Even in developed pools the later drilled wells do not ordinarily furnish the volume of gas that the wells did when the pools were first discovered.

The number of consumers of natural gas in New York in 1926 was 235,290, an increase of nearly 13,000 over the preceding year. The total amount of natural gas consumed, exclusive of any artificial gas mixed with it, amounted to 17,864,000 M cubic feet. Of this amount, 6,931,000 M cubic feet were produced in New York and 10,933,000 M cubic feet were piped from Pennsylvania. In addition to the amount of natural gas produced and consumed in the State, there was an additional production of 96,000 M cubic feet, of which 79,000 M cubic feet were piped into Pennsylvania and 17,000 M cubic feet into Canada.

In the table of production presented herewith are given production, value, price a thousand cubic feet of gas at points of consumption, and the number of producing wells for the years for which figures are available. The number of wells include only those that produce gas alone. The wells in the oil fields, nearly all of which produce some gas along with the oil, are not included.

Production of natural gas in New York since 1917

| YEAR | NUMBER OF WELLS | PRODUCTION IN M CUBIC FEET | VALUE | PRICE A THOUSAND CUBIC FEET (CENTS) |
|---|---|---|---|---|
| 1917 | 2 078 | 8 371 747 | $2 499 303 | 29.9 |
| 1918 | 2 114 | 8 460 583 | 2 820 000 | 33.3 |
| 1919 | 1 961 | 8 124 000 | 2 870 000 | 35.3 |
| 1920 | 1 972 | 8 419 000 | 3 195 000 | 37.9 |
| 1921 | 1 949 | 6 583 000 | 2 798 000 | 42.5 |
| 1922 | .......... | 6 947 145 | 3 379 000 | 48.6 |
| 1923 | .......... | 6 497 000 | 3 739 000 | 57.5 |
| 1924 | .......... | 6 196 000 | 3 632 000 | 58.6 |
| 1925 | .......... | 6 210 000 | 3 778 000 | 60.8 |
| 1926 | .......... | 7 027 000 | 4 499 000 | 64.1 |

## NATURAL-GAS GASOLINE

The production of 539,000 gallons of natural-gas gasoline in 1926 is the largest since the establishment of the industry in this State in 1911. As an industry, the extraction of gasoline from natural gas is a development of the present century, the first commercial plants having been erected in 1909. The success of the industry is dependent on supplies of natural gas containing a sufficient amount of gasoline vapor to make extraction of the gasoline profitable. Natural gas containing a considerable amount of vapor is termed a "wet" gas; when the amount is small it is known as a "dry" gas. The distinction between wet and dry gas is merely relative since what might be termed as a wet gas in one locality might be a dry gas in another. In practical operations the amount of gasoline obtained from 1000 cubic feet of natural gas varies from about one-third of a gallon to about five gallons. The average for all the natural gas treated in the United States is about one gallon a thousand cubic feet and this is about the amount recovered at plants located in New York State.

Different processes are employed in the extraction of gasoline from natural gas. The compression method is the one most generally employed but with relatively dry gases the absorption method is widely used. Both methods as well as a combination of the two processes are in use in this State. Another process recently introduced is known as the charcoal process. As yet this method has not been used in local plants.

The expansion of the natural-gas gasoline industry is dependent mainly on additional supplies of natural gas obtained from oil pro-

ducing wells, since it is gas from the oil wells that holds the highest gasoline content. Gas wells near the oil fields usually contain some gasoline vapor, while those remote from the oil fields are mainly dry. The collection of drip gasoline in the pipelines results from the condensation of the gasoline vapor contained in the natural gas. In view of the declining production of gas from the oil fields of New York, the growth of the industry must be dependent upon treating larger volumes of the gas now being produced. In other words, only a small fraction of the natural gas, having a recoverable gasoline content, has its gasoline extracted before being passed into the pipelines of the distributing natural gas companies. The extracting of gasoline from natural gas does not materially impair its usefulness for domestic consumption. In some cases the removal of the gasoline is a distinct advantage, especially in winter months, when the condensation of the gasoline interferes with the free movement of the natural gas in the conducting pipes.

Before being marketed as a motor fuel, the raw gasoline, which is highly volatile, is blended with naphtha or other distillate, thus forming a high grade commercial gasoline.

In statistics of production the quantities and values are based on the raw or unblended gasoline. Statistics previous to 1918 are not available, since in the period 1911–18 the output was included with other states in order to avoid showing individual production.

**Production of natural-gas gasoline in New York since 1918**

| YEAR | GALLONS | VALUE |
|---|---|---|
| 1918 | 218 131 | $55 405 |
| 1919 | 457 985 | 84 083 |
| 1920 | 411 078 | 75 576 |
| 1921 | 366 240 | 52 108 |
| 1922 | 506 200 | 61 415 |
| 1923 | 408 000 | 44 000 |
| 1924 | 476 753 | 49 639 |
| 1925 | 414 000 | 46 000 |
| 1926 | 539 000 | 66 000 |

## PEAT

Although the State contains large areas of peat, estimated at 1,500,000 acres, its production has never become a large or well-established industry. On a small scale peat has been produced in the State for more than 100 years. During the past ten years

production reported by the three or four firms has averaged less than 900 tons annually. The average selling price for the period was about $10.50 a ton. The small scale operations carried on in this State are typical of those in all other states where peat deposits exist. The smallness of the industry as a whole is evident when it is considered that the entire production of peat in the United States in 1926, as reported by the Bureau of Mines, amounted to but 61,936 tons, the output being reported by about 25 individuals or firms. The average price a ton received for peat produced in 1926 was $10.45.

### Peat as a Fuel

The fact that peat is successfully employed as a fuel in several European countries has served to maintain active interest by many owners of peat deposits as to possibilities for commercial exploitation of their peat beds. The commercial production of fuel peat is dependent upon successful competition with other fuels now in use. Such competition depends not alone upon cost of production for quantities of peat that will have equal heating values as compared with other fuels; consideration must be given also to adaptability as a substitute for other fuels, especially coal, and to the unwillingness on the part of the public to use peat until forced to do so by high prices and scarcity of other fuels.

Unless obtained from a drained peat bog, peat is usually saturated with water. In the wet state, peat may contain as much as 90 per cent of water. This condition involves a preliminary handling of 90 pounds of water for each ten pounds of peat obtained after drying. By air drying, the moisture content of peat may be reduced to 25 or 30 per cent. The water remaining in peat after air drying is largely water combined chemically in the peat and this can be removed only at temperatures considerably above normal air temperature. To remove the remaining water requires artificial heating in retorts with the consumption of fuel. In drying artificially, excessive temperatures result in the loss of combustible matter in the peat itself. Air-dried peat, containing about 25 to 30 per cent of water, has about one-half the heating value of commercial coal. In addition to its low heating value as compared to coal, peat has the disadvantage of being bulky, requiring large storage space, since a cubic foot weighs only about 20 pounds.

For domestic use, such as in a range or heater, peat will make either a slow or a quick fire, according to the draft, but as in the use of wood, it is difficult to keep the fire overnight. One of the

objections to peat for household use is the fine dust both from the peat and from the ashes. The amount of ashes, however, as compared with coal, is small.

A number of attempts to produce fuel peat on large scale operations through the use of specially designed machinery have not met with any marked success. In many sections it is impossible to carry on operations through the winter months, during which time the machinery must remain idle. In seasons of abundant rainfall air drying of peat is seriously interfered with, and peat must be put under cover or else dried artificially. The briquetting of peat, either alone or in combination with other fuels, while greatly facilitating its handling and use, has not resulted in a product that under present conditions can compete successfully with fuels now generally employed.

### Other Uses of Peat

The employment of peat as a fertilizer or as an ingredient in chemical fertilizers constitutes the main use of all the peat produced in this country. More than 90 per cent of the total production of peat is employed in this way. Next in importance is its use as an ingredient in stock foods. To a limited extent peat is also used as a packing material, and as an absorbent.

## PETROLEUM

The productive oil pools of the State, which are found in rocks of Devonian age, are all located in the southwestern part in the counties of Allegany, Cattaraugus and Steuben, with a few small producing wells in Chautauqua county. Outside of the counties mentioned no productive pools have been discovered anywhere in the State, although a considerable amount of drilling has been carried on in other localities. The western section of the State has been particularly well explored with the result that while numerous deeper gas-producing horizons have been found, none of them has had more than a mere trace of oil. Moreover, it may be stated that the basal Chemung beds, which dip to the south at a rate of about 40 feet to the mile, and in which are found all of the known oil sands, come to the surface a few miles north of the productive areas. As a result of this, only strata older and lower in the geologic series are found over much of western New York north of the oil field, and consequently, any oil, if present, must occur in rocks of older geologic age than those yielding the present supply.

The oil pools of the State comprise about 50,000 acres and may all be included in a rectangle 54 miles long in an east-west direction, and extending 12 miles north from the New York-Pennsylvania state line. As to locations of pools, we have in Cattaraugus county, the northern extension of the Bradford pool of Pennsylvania. This pool is the only one not entirely within the State. In addition to the Bradford pool, other pools in Cattaraugus county include the Chipmonk, Red House, Rice Brook, Humphrey and two small pools near the city of Olean. Production in Cattaraugus county is mainly from the Bradford and Chipmonk pools. The other pools are much smaller and the Red House and Rice Brook pools are practically exhausted. To the east, and situated entirely in Allegany county, nine miles distant from the Bradford pool, is the Richburg or Bolivar pool, the largest and most productive in the State. Other pools in Allegany county include the Scio pool, the most northerly producing pool in the Appalachian field, the Fords Brook pool, Madison Hill pool, the Potter or Mervine pool and the Fulmer Valley pools. The Andover pool is partly in Allegany county and partly in Steuben county. The Marsh pool, the most easterly of the producing pools, is entirely in Steuben county.

The entire oil region is part of a dissected plateau with elevations ranging from 1600 to 2500 feet above sea level. As a result of the variable topography of the region, the depth of the wells in the main pools and in some of the smaller ones varies from about 900 feet in the valleys to more than 2000 feet in the uplands. In several of the smaller pools, where oil sands occur at a higher position in the stratigraphic series, or are located higher on the dip, the depth of the wells may not exceed 500 feet.

Much of the oil region is rather heavily mantled by glacial drift, and over much of the glaciated territory rock outcrops are infrequent for a region of such marked relief. A portion of the oil fields is south of the terminal moraine and even here many of the preglacial valleys are deeply drift filled as the result of glacial stream and lake deposits. In some cases the courses of preglacial streams have been changed. The distance to bed rock in some of the valleys has been found to be as much as 300 feet, while 100 feet of drift is not uncommon. In the uplands the glacial deposits are much thinner, and bed rock is often less than 30 feet from the surface.

In general outline the oil sands are of a lenticular nature, the thicknesses of which vary greatly from place to place. In the larger Bradford and Richburg pools, however, fairly constant thick-

ness is maintained over considerable areas. In the more important and larger pools the reported thickness of the best producing sands varies from 30 to 60 feet. Thin shale breaks in the oil sands are present in most localities so that actual thickness of producing oil sand is generally overstated in the well logs. The average thickness of the sands for all the fields would probably not exceed 15 to 20 feet. Overlapping of sand lenses at slightly different horizons in the Chemung formation has at times caused perplexing problems for drillers, while distinctive sand lenses at nearly the same horizon have been equally confusing, and in some cases these interrupted sands between the lenses constitute the dry streak of the drillers.

The porosity of the sands that have been tested from both the Richburg and the Bradford pools is uniformly low. The range in porosity of six samples from good producing wells was between twelve and seventeen, figures which may be regarded as fairly representative. Higher porosities have been reported in a few cases. Variations in porosity of sands in the same well at different depths are not uncommon and are often due to the presence of shaly material or to greater cementation of the sand grains, either of which factors has the effect of lessening the pore space. In sands free from shale the quartz grains are seen to be very fine and the pore spaces correspondingly small, the latter an important factor in causing the sand to produce oil slowly and in contributing thus to the long life which most of the wells possess.

In structural position the oil fields lie just east of the axis of the great Appalachian geosyncline. The axis inclines gently toward the southwest, and the regional dip is in that direction. The local dips are very low and not easily determined, but minor anticlinal and synclinal folds are present. Where these occur and no salt water is present, the oil is found in the synclines. Absence of much salt water is a noteworthy feature. For the most part the pools are not outlain by salt water, and beyond the oil-producing limit the sand usually pinches out as in structures of the lens type. Where there is a clearly defined dip in the lens structure, only gas is found in the higher portion. The presence of salt water in beds either above or below the sand producing oil may be attributed in some cases to independent overlapping sand lenses.

The prevailing color of the New York State oils is dark green and, when held against the sunlight, a golden green. In a few localities the oil is almost black, while on the border of some of the fields a small amount is a light yellow. All the oils are of a high grade

with a paraffin base, and command the highest market prices. Specific gravity at 10° C varies from 38° B to 45° B, most operators reporting 42° B. Oil, amber in color, from some of the wells in the Chipmonk sand, which lies above the Bradford sand in Cattaraugus county, is reported to have a gravity as high as 47° B.

## Oil Production

The increase in annual production of oil which has taken place in recent years is the result of the use of improved methods such as restored pressure or "flooding," for obtaining additional amounts of oil from sands that for many years have been pumped. Since the amount of oil that has already been obtained from the sands has an important bearing on the amount that can be obtained in the future from these same sands, figures of past production are of special interest.

Satisfactory statistics of production of oil are not available previous to 1891, since in earlier years part of the output, mainly from Cattaraugus county, was combined with that of Pennsylvania. Certain estimates of the early production, however, have been arrived at as follows: Published figures of production for the whole Bradford field of New York and Pennsylvania from 1878 (at which time there were about 250 wells in New York State) to 1885 inclusive show 120,000,000 barrels. On the basis of the Pennsylvania geological reports, 5 per cent of this amount was credited to New York which gives a yield of 6,000,000 barrels for the period. The Allegany county production from the opening of the field in 1880 to the year 1885 inclusive, which covered the flush period in the State, has been published at 18,205,000 barrels. During the flush period annual production exceeded 5,000,000 barrels. The production from all the New York fields for the period of 1886 to 1890 inclusive, with the exception of the years 1888 and 1890, which were inserted by the writers, is from estimates published in the Mineral Resources of the United States. The estimated production is as follows:

| YEAR | BARRELS |
|---|---|
| 1886 | 2 151 486 |
| 1887 | 2 075 000 |
| 1888 | 1 985 983 |
| 1889 | 1 896 966 |
| 1890 | 1 740 998 |
| | 9 850 433 |

Statistics of production after 1890 are based on published figures from reports of pipeline companies, supplemented by reports from individual producers for small quantities of oil not accounted for in the pipeline records:

| YEAR | BARRELS |
|---|---|
| 1891 | 1 585 030 |
| 1892 | 1 273 343 |
| 1893 | 1 031 391 |
| 1894 | 942 431 |
| 1895 | 912 948 |
| 1896 | 1 205 220 |
| 1897 | 1 279 155 |
| 1898 | 1 205 250 |
| 1899 | 1 320 909 |
| 1900 | 1 300 925 |
| 1901 | 1 206 618 |
| 1902 | 1 119 730 |
| 1903 | 1 162 978 |
| 1904 | 1 036 179 |
| 1905 | 949 511 |
| 1906 | 1 043 088 |
| 1907 | 1 052 324 |
| 1908 | 1 160 128 |
| 1909 | 1 160 402 |
| 1910 | 1 073 650 |
| 1911 | 955 314 |
| 1912 | 782 661 |
| 1913 | 916 873 |
| 1914 | 933 511 |
| 1915 | 928 540 |
| 1916 | 874 087 |
| 1917 | 879 685 |
| 1918 | 808 843 |
| 1919 | 851 000 |
| 1920 | 906 000 |
| 1921 | 988 000 |
| 1922 | 1 000 000 |
| 1923 | 1 250 000 |
| 1924 | 1 440 000 |
| 1925 | 1 695 000 |
| 1926 | 1 956 000 |
| | 40 186 724 |

| | |
|---|---|
| Summary of production: | |
| N. Y. Bradford field 1878–85 | 6 000 000 |
| Allegany field 1880–85 | 18 205 000 |
| All New York fields 1886–90 | 9 850 433 |
| All New York fields 1891–1926 | 40 186 724 |
| Total | 74 242 157 |

By way of explanation of the foregoing tables, it may be mentioned that the annual increase in production beginning with 1919 is not due to expansion of the fields or the finding of new productive sands but rather to the introduction of flooding methods which are now being regularly employed in many sections of the New York

fields. In 1916, when 11,200 wells were producing, the average yield of a well was only one-fifth of a barrel a day. In 1926, with approximately 14,000 wells producing, the average daily production is about one-third barrel a day. It may be noted further that the 1926 production is the largest recorded in more than 35 years.

### Life and Future Development of the New York Fields

Both the Cattaraugus and the Allegany county oil fields have been producing for more than 47 years. Since 1899 there has been but little development of the new territory, nearly all of the new wells being drilled in the old pools between other wells. During the long period since these fields have been opened, the limits of the productive areas have been rather well established by border drilling. Although a small expansion of the present producing areas may be expected through the extension of spurs, it is not probable that there will ever be an important increase of productive territory. At the south the fields are limited by the Pennsylvania border, while on the north the basal part of the Chemung formation containing the oil-bearing series gradually rises and reaches the surface within a distance of 25 miles from the pools already developed. Neither to the east nor to the west of the present fields has deep drilling resulted in the finding of any important oil supplies. The discovery of a few small outlying pools is the most that can be expected. In the territory north of the present producing fields, a large number of wells have been drilled, and these have yielded only gas. It is therefore unlikely that the oil fields can ever be much extended in this direction.

The single chance of finding undiscovered supplies of oil of any importance in the present fields appears to be by deeper drilling. No deep tests have been made in the oil fields, but in the counties to the north some 1500 gas wells have been drilled, some of which went as low as the Trenton limestone, and in two or three instances are recorded as having reached the Precambrian. In only a few of these wells has there been a showing of oil, although two wells actually had small oil production.

One of the interesting features of the New York wells is their longevity. One well is still producing after a period of more than 48 years. Other wells are known that have produced for more than 40 years, while wells that have produced for more than 30 years are common. Of the 14,000 producing wells in the State, perhaps more than half the number have produced for a period exceeding

20 years. The fineness of the sand, low porosity and the low but ever-present gas pressure are the important factors contributing to the long life of the wells, while the low cost of upkeep and the high grade of oil produced make the pumping of the wells profitable even after daily production is but a small fraction of a barrel.

The future life and production of the oil fields are dependent upon a number of factors that do not apply to fields using the ordinary or natural methods of production. Before the introduction of flooding methods, when the annual production in the State had decreased to about three-fourths of a million barrels, it seemed that the end of life of the fields was close at hand. Under favorable conditions, however, the results of flooding give additional recoveries of from 2000 to more than 5000 barrels an acre. A conservative estimate of future production is 85,000,000 barrels as against past production of 75,000,000. Much larger estimates have been made but these have been based upon the assumption that favorable conditions for flooding will be found to exist in practically all the areas where flooding has not yet been tried. Owing to the fact that the floods travel slowly—from 50 to 200 feet a year—it would seem that even with an intensive program of flooding, the fields will continue to produce for a period of 30 to 50 years and that the production period under certain circumstances can be prolonged for even a greater length of time. In addition to flooding methods, a more extended use of air and natural gas, together with other possible new and improved methods for obtaining additional quantities of oil, as well as the cost of oil production, will be important factors in determining the length of time the fields will be operated.

## PYRITE

Pyrite at one time was the basis of substantial mining operations in the State, particularly during the war period when foreign ores and sulphur supplies were curtailed, and in the preceding years before the native sulphur industry assumed importance. The discovery and rapid development of the sulphur deposits of the coastal region of Louisiana and Texas have greatly curtailed the market for pyrite, since the latter can not be produced, as a rule, on a competitive basis with low-priced native sulphur. From its former position as a large importer of Sicilian sulphur and of foreign pyrites, the United States is now an exporter of refined sulphur. Most of the pyrite now sold is a by-product of the mining of other metals.

The use of pyrite is in acid manufacture, for which, of course, the sulphur component is alone of importance. Theoretically the

mineral contains 53.4 per cent of sulphur, but the average material as shipped ranges from 45 to 50 per cent. The spent cinder, after combustion of the sulphur to form sulphur dioxide—the first stage in the making of sulphuric acid—has found employment to some extent in blast furnaces. The cinder has the composition of hematite (ferric oxide), and if the roasting is carried to the point of complete removal of the sulphur, it is practically as good for iron manufacture as the natural hematite ores.

Since 1920 all of the pyrite that appears in the table of production has been recovered as a by-product of the zinc-mining industry. The working of deposits for pyrite alone was discontinued in that year. Information about the present sources of the shipments will be found under the title "Zinc" elsewhere in this report.

The principal deposits of pyrite are found on the northwestern side of the Adirondacks in the belts of gneisses and schists which are associated with the crystalline limestones of that region. The deposits consist of bands of the schists, from a few feet to 50 feet or more wide and of indefinite length along the strike, that carry a network of small veins and stringers of iron sulphides in a quartz and chlorite gangue. Pyrrhotite as well as pyrite is found in some localities, but as a rule is confined to definite areas of the schists. The sulphur content in the crude ore averages around 25 per cent. Concentration is necessary to make a commercial product.

The principal shippers in the district have been the Stella mines near Hermon, last operated by the St Lawrence Pyrite Co., the Cole mine near Gouverneur worked by the New York Pyrite Co., and the mines at Pyrites formerly worked by the High Falls Pyrites Co. and the National Pyrites Co. All the mines named are in St Lawrence county. Similar ore bands are found in the contiguous area of Jefferson county, where their weathered outcrops locally have been utilized for iron ore. The deposits near Antwerp and Oxbow may be cited as among the larger and richer occurrences in that county.

The distribution and geology of the pyrite bodies are described in the report of A. F. Buddington, published as Bulletin 1 of the New York State Defense Council ('17, p. 1–40). Their economic features are dealt with by F. A. Vogel in The Mineral Industry, v. 16, ('08, p. 845–51) and by D. H. Newland in New York State Museum Bulletin 223–24, ('21, p. 209–18). The origin of the ores has been discussed by C. H. Smyth, jr, in New York State Museum Bulletin 158 ('12, p. 143–82).

**Production of pyrite in New York since 1904**

| YEAR | LONG TONS | VALUE |
|---|---|---|
| 1904 | 5 275 | $20 820 |
| 1905 | 10 100 | 40 465 |
| 1906 | 11 798 | 35 550 |
| 1907 | 49 978 | 162 430 |
| 1908 | 23 775 | 104 798 |
| 1909 | *a* | ....... |
| 1910 | 37 270 | 175 791 |
| 1911 | 53 453 | 251 466 |
| 1912 | 58 137 | 286 577 |
| 1913 | 54 903 | 242 065 |
| 1914 | 61 513 | 266 930 |
| 1915 | 57 241 | 265 362 |
| 1916 | *a* | ....... |
| 1917 | 57 075 | 354 000 |
| 1918 | 63 982 | 422 958 |
| 1919 | 60 544 | 468 257 |
| 1920 | 30 753 | 261 575 |
| 1921 | *a* | ....... |
| 1922 | 5 900 | *a* |
| 1923 | 11 000 | *a* |
| 1924 | 7 593 | 16 705 |
| 1925 | 12 000 | 27 000 |
| 1926 | 7 635 | 17 176 |

[a] Figures can not be disclosed.

## SALT

The salt industry has a long record of activity and is probably the oldest of the mineral industries that still maintain their importance in the State.

Its early history bears directly upon the exploration and settlement of the interior region. The rich natural brines within the limits of what is now Onondaga county were frequented by the native Indian tribes, who probably made salt and traded in it before the advent of European explorers. At any rate they revealed their existence to the first missionaries, the Jesuit Fathers, who visited the Onondaga springs as early as 1646 and who gave accounts of the remarkable salinity of the waters in the reports or "Relations" submitted to the home office. Traders and Indians sold the salt to the early Dutch and English settlers. The springs were the most accessible within a wide territory, for they were on a main line of communication between the Hudson river and the Great Lakes, with waterways navigable by small boats over most of the distance.

With the organization of the State Government and the opening of the interior lands for settlement, the manufacture of salt began

as a permanent industry. The first establishment of more than temporary character consisted of an arch of four kettles erected in 1793. Many small enterprises of this character were rapidly set up in the next few years and to avoid controversy over their respective rights to the brines, the Legislature of New York State in 1797 passed regulations to control operations within the Onondaga Salt Springs reservation, and appointed a superintendent on the ground.

Plans to locate the rock salt beds that gave rise to the brines were initiated as early as 1820, but the early borings were all situated too near the outcrop, in the leached zone of the salt strata. The discovery of salt in place was not made until 1865, when a well drilled at Vincent, Ontario county, first penetrated a bed.

The brine industry received a strong impetus from the construction of the Erie canal (1825), which was laid out to pass directly through the larger districts at Salina and Syracuse. One of the important objectives of this waterway was to provide better shipping facilities for the industry, so as to lower the costs to consumers in the outlying territory.

Solar evaporation was introduced at about this time and provided a cheap method for making coarse grades of salt; it soon acquired greater importance than the artificial evaporation method and continued a flourishing industry until the salt mines were opened, after which the output gradually declined.

About 1880 interest began to develop in the rock salt resources, as it was found that continued use of the natural brines was bringing about a decided lowering of the saline contents and thus adding to the expense of evaporation. Exploration of the beds was carried on over a wide territory and practically marked out their limits as they now are known. When wells were sunk into the beds water could be brought into contact with the salt so as to produce a concentrated solution carrying about 25 per cent of saline constituents as against 16 or 17 per cent for the natural brines weakened by nearly a century of pumping. Evaporating plants were established in many of the central and western counties on the basis of the rock salt beds, which were reached at depths of from 800 to 2300 feet, according to the position of the wells and the surface contours. Wyoming, Warsaw, Rock Glen, Silver Springs, Watkins (now Watkins Glen), Ludlowville, Ithaca and Tully were some of the places at which the rock salt was exploited by borings.

The first mine opening to be bottomed in salt was that of the Retsof Mining Co., which completed a shaft at Retsof, Livingston

county, in 1885. The depth was a little over 1000 feet. Operations are still maintained at that place. The Greigsville Mining Co. put down a shaft just west of the Retsof mine, the Lehigh Mining Co. another, two and one-half miles south of Le Roy, Genesee county, and the Livonia Salt Mining Co. one at Livonia, Genesee county. All these companies later were taken over by the Retsof Mining Co. and the mines were shut down. The Sterling Salt Co. began production at Cuylerville, Genesee county, in 1906. The last shaft to reach the salt is that at Myers, Tompkins county, now operated by the Cayuga Rock Salt Co., Inc. It is the deepest of the workings in the salt, having about 2000 feet vertical depth.

## Production and Trade

Salt is produced in New York for consumption in the following forms: rock salt obtained by mining; solar evaporated salt from natural brines; fine salt made by vacuum pans and grainers from artificial brines, or solutions obtained from underground rock salt; and salt in brines used for chemical manufacture without evaporation.

Rock salt undergoes no preparation other than crushing and screening. A small quantity is sold in lump form as it comes from the mine, mainly as cattle salt. The rest is passed through a breaker at the top of the shaft where it undergoes reduction by rolls and screening to form five graded sizes from three-quarters to one-sixteenth of an inch in diameter. The fines or undersizes are disposed of by sale to chemical plants for alkali and chlorine manufacture, or are compressed into bricks for cattle salt. The graded sizes are employed in refrigeration, the curing of fish and hides, and in many other industries.

Solar evaporated salt, once an important item of the local production, is now made on a small scale. It is used for the same purposes practically as rock salt, but contains less of the common impurities which are mostly removed by fractional crystallization. The evaporation is carried out in shallow vats or pans in three stages, of which the first two remove the less soluble impurities — iron and lime compounds — and the third precipitates the salt. It is an economical method of making salt, since it requires no fuel and very little labor, but is dependent for its success upon favorable seasonal conditions.

Fine salt is the product of rapid evaporation in open pans, grainers and vacuum pans. The speed of evaporation determines the size of the crystal particles or the grain of the salt. Vacuum pans, in which

the boiling temperatures are much below the boiling point under atmospheric conditions, produce the smallest sizes. Most of the fine salt is now made in such pans, which are actually not pans but vertical cylinders of sheet steel terminated at each end by a cone of the same construction. Heat is applied by circulating steam in the interior of the cylindrical part and the vacuum is maintained by means of a pump connected with the upper cone. Grainers are long open vats heated by steam pipes running the length of the vat about a foot from the bottom, which are kept immersed in the brine. The salt crystallizes out in rather coarse particles, many of them crystal aggregates. Grainers are combined in some plants with vacuum pans, so as to give a range of sizes larger than that secured by either system alone. Open pans of boiler iron set in brick arches have nearly gone out of use on account of their relatively high fuel consumption and their liability to warp and buckle under the heat.

The production of salt during 1925 and 1926, listed according to kinds as far as practicable, is shown in the accompanying tables. Rock salt constitutes nearly one-half of the total. The next most important item is the salt consumed as brine without evaporation for chemical manufacture, on which a very low value is placed. The fine salt from evaporation in vacuum pans and grainers accounts for about 20 per cent of the total.

Complete figures of production are available from 1797 on, and their compilation shows the aggregate output up to and including the year 1926 to have been 433,591,052 barrels or 60,702,747 short tons.

## Salt in Chemical Manufacture

The conversion of salt into various commercial chemicals is the basis of an important industry in New York and accounts for a considerable part of the annual production and consumption in the State. The chemicals thus manufactured include caustic soda, bleaching powder, soda ash, sodium bicarbonate and chlorine. The works are situated at Niagara Falls and at Solvay, near Syracuse. At the former place the manufacture is carried out by electrochemical methods, utilizing power from the falls and rock salt shipped from the mines in western New York. The Solvay works use the well-known ammonia process, which requires both limestone and salt as base materials. Salt is piped to the plant in the form of brine taken from wells situated in the town of Tully, and limestone is quarried in the vicinity of Jamesville.

## List of Brine Plants

The following are the manufacturers of evaporated salt and the miners of rock salt in New York State in 1925 and 1926. The evaporating plants were operated by LeRoy Salt Co., LeRoy; Thomas Gale, Syracuse; Thomas P. Murray, Liverpool; Kerr-Remington Salt Co., Inc., 516 N. Delaware avenue, Philadelphia, Pa.; International Salt Co., Inc., Scranton, Pa.; Watkins Salt Co., Watkins Glen; Worcester Salt Co., 71 Murray street, New York; Solvay Process Co., Syracuse.

Rock salt mines were operated by: Sterling Salt Co., 29 Broadway, New York; Retsof Mining Co., Scranton, Pa.; and Cayuga Rock Salt Co., Inc., Myers.

**Production of salt by grades in 1925**

| GRADE | BARRELS | VALUE | VALUE A BARREL |
|---|---|---|---|
| Evaporated: | | | |
| Grainers and open pans | 1 034 214 | $1 001 238 | $ 97 |
| Vacuum pans | 1 676 857 | 2 084 695 | 1 24 |
| Rock salt | 7 174 214 | 3 745 411 | 52 |
| Other kinds: | | | |
| Solar; Pressed blocks from rock salt; Salt consumed as brine | 4 785 929 | 301 900 | ........ |
| Total | 14 671 214 | $7 133 244 | ........ |

**Production of salt by grades in 1926**

| GRADE | BARRELS | VALUE | VALUE A BARREL |
|---|---|---|---|
| Evaporated: | | | |
| Grainers and open pans | 858 929 | $823 227 | $ 96 |
| Vacuum pans | 1 868 571 | 2 267 856 | 1 21 |
| Rock salt | 6 282 500 | 3 154 430 | 50 |
| Other kinds: | | | |
| Solar; Pressed blocks from rock salt; Salt consumed as brine | 5 287 000 | 319 316 | ........ |
| Total | 14 297 000 | $6 564 829 | ........ |

## SAND AND GRAVEL

The abundance of sand and gravel in the State is a natural advantage whose importance, perhaps, is not generally appreciated. So widespread are the deposits that supplies for the usual building purposes are obtainable in almost every county and in the vicinity of all the larger cities. They contribute substantially to the convenience and economy of construction work, in which they are the cheapest and for certain operations the most bulky of the required materials. Since their costs are proportionate more or less to the distance of the market, deposits close at hand usually imply an inexpensive rock aggregate available at all times for the requisite needs.

Building sand is only one, although the main, item of production. Molding sand occurs in certain limited areas, particularly in the Hudson valley, where it is worked on an extensive scale. The material is shipped to many points beyond the State limits, in fact as far away as the Pacific coast. Glass sand is another special grade that has a local distribution. Fire sand, filter sand, abrasive sand and other kinds are included in the list of products.

The recent growth of the building sand business, as indicated by the accompanying statistical tables, has been accompanied by important changes in the methods of producing and handling the output. Formerly this work was carried on by a great number of small enterprises with a minimum of equipment, operating seasonally according to the variable market requirements, and showing a notable turnover in the active list from year to year. These conditions have been largely removed, although they are still to be found in the more remote sections. The main part of the production, which is tributary to the larger centers of population and industry, is now supplied by establishments which represent large outlays for equipment to handle and transport the materials and which consequently are in the nature of permanent enterprises.

Another factor that has contributed to the stabilization of the trade is the more rigid standards now in effect as to the grading of the aggregates used in construction. This has resulted in a selective development of resources in many districts on the basis of physical and chemical tests. It has also led to the increased use of mechanical preparation in the way of sizing and washing of the materials.

## Production

In earlier years the statistical summaries of the industry were incomplete and the figures could be regarded as approximations only. The recent figures may be accepted as more reliable in view of the relative importance of the large, more or less permanent, enterprises to those of transitory nature for which information is difficult to obtain.

The aggregate value of the sand and gravel shipped in 1926 was $11,585,652, representing a total of 19,334,360 tons of these materials. Both tonnage and values were considerably in excess of the figures for any previous year. In 1925 the value was $9,750,433 and the quantity 14,966,616 tons. Both years were characterized by very active building operations, which may be held accountable for the large volume of the shipments.

**Shipments of sand and gravel 1924–26**

| MATERIAL | 1924 | | 1925 | | 1926 | |
|---|---|---|---|---|---|---|
| | Short tons | Value | Short tons | Value | Short tons | Value |
| Building sand | 8 542 247 | $4 330 551 | 9 376 634 | $4 788 322 | 11 975 851 | $5 647 668 |
| Molding sand | 607 089 | 1 040 735 | 671 610 | 1 147 072 | 671 748 | 1 171 821 |
| Fire or furnace sand | 5 743 | 4 481 | 10 260 | 8 850 | 24 300 | 20 220 |
| Other sand | 144 907 | 95 833 | 143 773 | 95 579 | 145 691 | 83 140 |
| Gravel | 4 097 554 | 3 111 593 | 4 764 339 | 3 710 610 | 6 516 770 | 4 662 803 |
| Total | 13 397 540 | $8 583 193 | 14 966 616 | $9 750 433 | 19 334 360 | $11 585 652 |

## Building Sand and Gravel

The reports from sand and gravel pits worked for building and engineering construction purposes showed total shipments in 1926 of 11,975,851 short tons of sand valued at $5,647,668 and 6,516,770 short tons of gravel valued at $4,662,803. These figures compare with 9,376,634 short tons ($4,788,322) of sand and 4,764,339 short tons ($3,710,610) of gravel in 1925.

As might be supposed, the largest shipments of these materials were for the New York city market. The principal sources were the deposits on Long Island, chiefly in Nassau and Suffolk counties, where the extraction, preparation and shipment of the materials have long since been carried on by permanent enterprises operating throughout the year. Roslyn, Glen Cove, Port Washington, Northport, Farmingdale and Port Jefferson were the larger shipping points. The sands were obtained from morainal accumulations

that form bluffs along the shore line and in part from the beaches, where the sands have been subjected to sorting and washing by wave action. They contain a high per cent of quartz and make a strong durable building aggregate. The shipments from this district in 1926 amounted to 8,370,574 short tons of building sand, valued at $3,130,940 and 2,426,952 short tons of gravel valued at $1,819,596. The average value of the sand in 1926 was $0.37 a ton and of the gravel $0.75 a ton, at the point of shipment.

The Hudson river region contains several banks of more or less modified glacial sand and gravels which supply the needs of the cities along the river. In Ulster county the production is also distributed to the metropolitan markets. This county reported a total of 238,198 tons of sand ($198,730) and 196,800 tons of gravel ($280,009) as forwarded in 1926.

Albany and Rensselaer counties, which are contiguous and include the principal enterprises in the upper Hudson valley, reported a total of 217,293 tons of sand ($113,912) and 113,261 tons of gravel ($186,731) for the same year.

Oneida county is favored by the occurrence of high-grade beach sands which are found on the shores of Oneida lake and in the higher beaches left by postglacial subsidence of the waters. There are also morainal deposits that yield coarser aggregates. Shipments are made to many of the towns and cities in the interior of the State. The reported products for 1926 were 272,148 short tons of sand ($155,385) and 24,320 short tons of gravel ($23,130).

In the western part of the State, Rochester and Buffalo are important markets and draw supplies from several counties, including Monroe, Livingston, Cattaraugus and Erie as the principal ones. The combined totals in 1926 for the four counties named were 2,156,871 tons of sand ($1,494,394) and 3,259,686 tons of gravel ($2,096,384).

## Molding Sand

The molding sand trade is a separate branch of the sand industry, carried on by a few shippers experienced in the requirements of the foundries which represent the market. A firm usually operates a number of properties at one time so as to have an assortment of grades from which to select material adapted to particular classes of foundry work. The sand is excavated by hand work and no mechanical sizing or other preparation is done at the bank. The selection and grading of molding sand in the field is largely a matter of skill acquired by long familiarity with the business.

The production of molding sand does not vary much from year to year. In 1926 the shipments totaled 617,748 short tons ($1,171,821) and in 1925, 671,610 short tons ($1,147,072), while in 1916 a total of 661,673 short tons was reported. This feature reflects the wide extent of the selling territory for the local product, which is probably shipped over a larger area than any other molding sand in the country.

The molding sands are obtained mostly from the Hudson valley in the stretch of 100 miles or more from Saratoga county on the north to Dutchess county on the south. The product from this region bears the general trade name of Albany molding sand, although it is shipped from many points in Saratoga, Rensselaer, Greene, Columbia and Dutchess counties as well as Albany county. The sands are the uppermost layers of the terraced lake beds that are prominently developed within the valley and which stand at elevations of from 150 to 400 feet above sea level. They rest upon the sedimentary or "varved" brick clays which with the sands were accumulated in the closing stages of the Glacial period when the valley was occupied by the flood waters of Lake Albany.

The molding sand occurs directly below the soil and is seldom more than two or three feet thick. Its removal consists in the skimming off of a thin horizontal layer rather than working a deep bank as in the usual building sand operations, so that excavating machinery is of little use. The land under exploitation is divided off into sections according to the various qualities of sand present and the sod is stripped down to the layer. This operation is usually performed in successive trenches, each about three feet wide, so that the sod and soil of one bench is placed in the trench left by the removal of the sand from the preceding operation. After a plot has been worked in this way the land may be returned to agriculture without much deterioration of value. The right of digging the land is usually let on contract, the shipper paying a lump sum or a certain amount for each ton removed. The yield obtainable is figured roundly at 1000 tons to the acre for each six inches of thickness, an 18-inch layer which is about the average size will yield thus 3000 tons for each full acre of surface.

The grades of sand shipped from the Hudson valley run from No. 0, the finest, to No. 4, which is the coarsest size that is commonly produced in the district. No. 0 is used in stove plate and fine castings and consists of sand of which 95 to 98 per cent will pass a No. 100 screen or of which the average grain diameter is smaller

than .147 mm. (.0058 inch). No. 0 and No. 1 are the sizes for which the chief demand exists since they are not common in the molding sand districts elsewhere.

### Glass Sand

A few thousand tons of glass sand are shipped each year from the vicinity of Oneida lake. The deposits are water-worked sands that occur in blanket layers of from six inches to three feet thick. At one time they were the support of a local window glass industry of considerable importance, but in recent years the output is shipped to other places for manufacture. After screening and washing the sand shows a content of around 98.5 per cent silica, with about .2 per cent ferric oxide.

### Fire or Furnace Sand

This is a high silica sand that finds use in the lining of metallurgical furnaces, principally iron and steel furnaces. The qualities required are uniform grain and the ability to resist corrosion by molten metal and gases. Sand for this use is obtained in the Oneida lake region and on Long Island. The shipments for 1926 were 24,300 short tons ($20,220) against 10,260 tons ($8,850) in 1925.

### Filter Sand

Municipal water purification plants make use of a special grade of sand to form the beds of gravity filters. Standard specifications in regard to grain diameter, porosity and composition prevail for the material. The practical qualifications are that the sand be clean, free of clay and lime, and possess a degree of porosity that will admit of the passage of water readily, but retains the mechanical and organic impurities. A high quartz sand is preferred. The source of supply is the Long Island beds. The shipments amount to 10,000 tons or more a year.

### Engine Sand

This is sold to railroads for use by locomotives. A clean quartz sand of medium texture is required. The shipments in 1926 amounted to 118,056 short tons ($62,899) as compared with 111,557 short tons ($63,750) in 1925.

## Directory of Sand and Gravel Producers

Firms reporting production of molding sand are indicated by the letter "m."

| NAME | ADDRESS | LOCATION OF PIT |
|---|---|---|
| | *Albany county* | |
| Albany Sand & Supply Co. (m) | Box 28, Albany | Delmar, Glenmont, Slingerlands, Wemple |
| Edward J. Smith (m) | 170 Second av., Albany | Albany |
| Albany Gravel Co., Inc | Albany | Albany |
| Whitehead Bros. Co. (m) | 537 W. 27th st., New York City | Albany, Selkirk, Wemple, Glenmont, Slingerlands, Delmar, West Albany |
| F. A. Hillman (m) | South Amboy, N. J | Albany |
| N. Y. Sand & Facing Co. (m) | 106 Grand av., Brooklyn | Albany, Glenmont, Selkirk |
| Paxson-Taggert, Inc. (m) | Luzerne & D sts., Phila., Pa. | Selkirk |
| Thomas F. Evers (m) | Waterford | West Albany |
| Chas. Gibbons & Sons (m) | Stuyvesant | Selkirk |
| W. Albany Moulding Sand Co. (m) | 1050 Madison av., West Albany | West Albany |
| Wade Co., Inc | New Baltimore | New Baltimore |
| | *Allegany county* | |
| Frank W. Sterrett, Inc | 42 Broadway, Hornell | Alfred |
| L. S. Gessler & Son | Fillmore | Fillmore |
| | *Broome county* | |
| Stewart Sand & Gravel Co | Binghamton | Chenango Bridge |
| Chenango Valley S. & G. Co | 404 Court st., Utica | Whitney Point |
| | *Cattaraugus county* | |
| J. E. Carroll Sand Co | 2009 Liberty Bank Bldg., Buffalo | Attica, Franklinville |
| Allegany Sand & Gravel Co | Olean | Allegany |
| Whitehead Bros. Co. (m) | 537 W. 27th st., New York City | Allegany |
| American Radiator Co. (m) | 1807 Elmwood av., Buffalo | Olean |
| C. C. Hatch (m) | 62 Inson st., Buffalo | Olean, Vandalia |
| Olean Sand & Gravel Co | Olean | Machias Junction |
| | *Cayuga county* | |
| Ludke Bros | 33 Hockeborn av., Auburn | Auburn |
| J. W. Robinson (m) | R. D. 7, Auburn | Auburn |
| Patrick Walsh (m) | R. D. 1, Auburn | Auburn |
| Eldredge & Robinson | 126 Genesee st., Auburn | Fair Haven |
| Geo. Snyder | Auburn | Auburn |
| | *Chautauqua county* | |
| Builders Supply Co | Jamestown | Jamestown |
| Sebold Bros | Dunkirk | Dunkirk |
| | *Chemung county* | |
| Holleran Bros | Elmira | Elmira |
| G. M. Baldwin S. & G. Co | Horseheads | Horseheads |
| | *Chenango county* | |
| Chenango Valley S. & G. Co | 404 Court st., Utica | Sherburne |
| | *Clinton county* | |
| Rutland R. R. Co | Rutland, Vt | Churubusco |
| | *Columbia county* | |
| Chas. Gibbons & Sons (m) | Stuyvesant | Stuyvesant |
| Empire Brick & Supply Co | 103 Park av., New York City | Stockport |
| Whitehead Bros. Co. (m) | 537 W. 27th st., New York City | Stuyvesant |
| | *Delaware county* | |
| J. P. Davis | Hancock | Hancock |
| Hawk Mountain Sand Co | Hancock | Sand Switch |
| Johnson & Bojo | Horton | Tylers Switch |
| | *Dutchess county* | |
| Whitehead Bros. Co. (m) | 537 W. 27th st., New York City | Camelot, Clinton Point, New Hamburg |
| N. Y. Sand & Facing Co. (m) | 106 Grand av., Brooklyn | New Hamburg |
| Poughkeepsie Sand & Gravel Co | Poughkeepsie | Poughkeepsie |

| NAME | ADDRESS | LOCATION OF PIT |
|---|---|---|
| | *Erie county* | |
| Buffalo Gravel Corp | 19 Hudson st., Buffalo | Buffalo |
| Genesee Washed Gravel Corp., Inc. | 207 Crosby Bldg., Buffalo | Bowmanville, |
| Gravel Products Corp | 78 Perry st., Buffalo | Buffalo |
| Seneca Washed Gravel Corp | 72 Pearl st., Buffalo | Buffalo |
| Squaw Island S. & G. Corp | 78 Perry st., Buffalo | Buffalo |
| Clarence Supply Co | Clarence | Clarence |
| East Aurora S. & G. Co. | 66 Blaine av., Buffalo | East Aurora |
| Springville S. & G. Co | Springville | Springville |
| Sterrett S. & G. Corp | Springville | Springville |
| Daigler Sand & Gravel Co | Williamsville | Williamsville |
| | *Essex county* | |
| Doud Concrete Products Co | Saranac Lake | Saranac Lake |
| Boyce & Roberson | Saranac Lake | Saranac Lake |
| | *Franklin county* | |
| Smith & Trotter | Santa Clara | Santa Clara |
| John Para | Malone | Malone |
| | *Genesee county* | |
| E. J. Boatfield | LeRoy | LeRoy |
| F. Munt & Son | LeRoy | LeRoy |
| Niagara Gypsum Co | 597 Michigan av., Buffalo | Oakfield |
| U. S. Gypsum Co | 300 W. Adams st., Chicago, Ill. | Oakfield |
| John W. Stevens | 58 W. Main st., LeRoy | LeRoy |
| | *Greene county* | |
| N. Y. Sand & Facing Co | 106 Grand av., Brooklyn | Coxsackie |
| Whitehead Bros | 537 W. 27th st., New York City | Coxsackie, Hotaling, Four Mile Point |
| | *Jefferson county* | |
| N. Y. C. Ry. Co | 466 Lexington av., New York City | Calcium |
| G. T. Brady | Burrville Road, Watertown | Watertown |
| O. B. Colwell | Watertown | Watertown |
| R. T. Loughlin | R. D. 1, Watertown | Watertown |
| W. H. Luther | R. D. 1, Watertown | Watertown |
| G. W. Newman | R. D. 1, Watertown | Watertown |
| Peter Bigham | Watertown | Watertown |
| | *Kings county* | |
| Jacobus Grauwiller Co. (m) | 15 Moore st., New York City | Jamaica Bay |
| Atlantic Coast Sand Co. (m) | 15 Moore st., New York City | Jamaica Bay |
| | *Livingston county* | |
| Consolidated Materials Corp | 605 Terminal Bldg., Rochester | Scottsville (Caledonia) |
| Valley Sand & Gravel Corp | 1402 Lincoln Alliance Bank Bldg., Rochester | Canawaugus, Caledonia, Wadsworth |
| Town of Livonia | Livonia | Livonia |
| Livonia Cement Block Factory | Livonia | Livonia |
| John Shelley | Livonia | Livonia |
| Verne Weidman | Mount Morris | Sonyea |
| | *Madison county* | |
| Rock Cut Stone Co | Syracuse | Ballina |
| Madison Sand & Gravel Co | Hamilton | Solsville |
| | *Monroe County* | |
| C. A. Schrader | R. D. 2, 1054 Highland av., Rochester | Brighton |
| Anthony & Moss | Pittsford | Pittsford |
| John E. Redmond | 43 Bengal ter., Rochester | Rich's Dugway |
| Scottsville S. & G. Co | Scottsville | Scottsville |
| Newport S. & G. Corp | Powers Bldg., Rochester | Irondequoit |
| Lake Ontario Sand Co. (m) | Charlotte | Rochester |
| Perry-Baetzel Sand Co | 438 Exchange st., Rochester | Pittsford, Bushnell's Basin |
| Geo. Amish & Sons | 648 Mount Read blvd, Rochester | Rochester |
| John Schwalback (m) | 1283 Clinton av. S., Rochester | Rochester |
| Hutcheson Sand & Stone Corp | 555 Garson av., Rochester | Rochester |
| Palumbo Bros., Inc | Buel st., Rochester | Rochester |
| E. C. Goodberlet & Son | R. D., Coldwater | Rochester ("Buell Road") |
| Star Sand & Gravel Co | Brighton Station, Rochester | Brighton |
| Elam Sand Co | Lindon rd, Brighton, Rochester | Brighton |

| NAME | ADDRESS | LOCATION OF PIT |
|---|---|---|
| | *Montgomery county* | |
| John Rossi | 12 Sloane st., Amsterdam | Amsterdam |
| | *Nassau county* | |
| Willard Sand & Gravel Co. (m) | Farmingdale, Long Island | Farmingdale |
| Hinckle & Finlayson | Glen Cove | Glen Cove |
| Nassau Sand & Gravel Co | 17 Battery pl., New York City | Roslyn |
| Hendrickson Bros | Valley Stream | Hewlett, Valley Stream |
| H. J. Taylor | Lynbrook | Lynbrook |
| Goodwin-Gallagher S. & G. Corp | 21 E. 40th st., New York City | Roslyn |
| Hunt-Drury Gravel Corp | Mineola | Mineola |
| Hygrade S. & G. Co., Inc | P. O. Box 456, Mineola | East Williston |
| Land Improvement & Supply Co | 808 Diamond Bank Bldg., Pittsburgh, Pa. | Port Washington |
| J. L. Walsh | Northport | Northport |
| O'Brien Bros. S. & G. Co | Port Washington | Port Washington |
| Dent & Kent, Inc | Rockville Center | Rockville Center |
| Westbury S. & G. Co | Westbury | Westbury |
| P. & R. Sand & Gravel Co | Lynbrook | Lynbrook |
| Long Island Construction Co | Central Park | Central Park |
| DePasquali Bros | Mineola | Mineola |
| | *Oneida county* | |
| Boonville Sand Corp. (m) | 404 Court st., Utica | Boonville, Forestport |
| Oneida Sand Co. of Boonville | Boonville | Boonville |
| W. E. Nelson | Washington Mills | Clayville |
| Pierce, Butler & Pierce Mfg. Co. (m) | Eastwood | Forestport |
| H. H. McKee & Sons, Inc | Box 254, Rome | Humaston |
| A. L. Gifford | 774 W. Dom st., Rome | Rome |
| E. J. Byam | Rome | Rome |
| Henry Hannicker | 201 Expense st., Rome | Rome |
| G. Adam Miller | Sylvan Beach | Sylvan Beach |
| Clean Sand & Gravel Co | Boonville | Boonville |
| Fike Bros | Rome | Rome |
| G. W. Bryant | McConnellsville | McConnellsville |
| | *Onondaga county* | |
| James Ready | Syracuse | Syracuse |
| F. W. Trowbridge | R. D. 4, Syracuse | Solvay |
| John Johnson | Alice st., Solvay | Solvay |
| B. D. Hyde | 904 Second st., Solvay | Syracuse |
| Joseph Piscitell | 131 W. Brighton av., Syracuse | Syracuse |
| S. F. Clough Sand & Stone Co | 1509 S. Salina st., Syracuse | Syracuse |
| Lowery Bros | 528 W. Colvin st., Syracuse | Syracuse |
| W. F. Saunders & Sons, Inc | R. D. 1, Nedrow | Syracuse |
| F. P. Morton | Syracuse | Syracuse |
| Martin Quigley | R. D. 4, Syracuse | Syracuse |
| C. H. Butler | South Onondaga | South Onondaga |
| McCarthy Bros. S. & G. Prod | Syracuse | Syracuse |
| Hogan | Syracuse | Syracuse |
| James Knox | Syracuse | Syracuse |
| | *Ontario county* | |
| Nathan Oaks & Sons | Oaks Corners | Oaks Corners |
| George A. Rogers | 34 Fairgate st., Rochester | Fishers |
| | *Orange county* | |
| Otisville Sand & Gravel Co. (m) | Otisville | Otisville |
| The Jova Brick Works | Roseton | Roseton |
| Stephen S. Decker | Warwick | Warwick |
| Boverman & Wilbur | Otisville | Otisville |
| Shaw & Reynolds | Port Jervis | Port Jervis |
| N. Y. Ontario & Western R. R | Grand Cent. Terminal, New York City | Huguenot |
| Hudson Sand & Gravel Co | Newburgh | Newburgh |
| Newburgh Bldg. & Supply Co | 448 Broadway, Newburgh | Newburgh |
| | *Orleans county* | |
| Clyde Pickett & Son | Albion | Albion |
| W. J. Gallagher | Medina | Medina |
| N. Y. C. Ry. Co | New York City | Kent |
| S. A. Wright | Waterport | Waterport |
| O'Donnell Bros | Medina | Medina |

| NAME | ADDRESS | LOCATION OF PIT |
|---|---|---|
| | *Oswego county* | |
| Oneida Lake Sand Mines (m) (glass, etc.) | Cleveland | Cleveland |
| Butler Bros | 123 Sabine st., Syracuse | Fulton, Minette |
| Fulton Sand & Gravel Co | 212 Park st., Fulton | Fulton, East Highland |
| Massara Washed S. & G. Co | Fulton | Fulton |
| Lacona S. & G. Corp | Watertown | Lacona |
| Patrick Fraser | Minetto | Minetto |
| | *Otsego county* | |
| Mohawk Limestone Prod. Co | Mohawk | Bloods Mills |
| | *Queens county* | |
| Oak Sand & Gravel Co | Bayside | Bayside |
| Rockaway White Sand Co | 160 Fifth av., New York City | Rockaway |
| Astell White Sand Co | 90 W. Broadway, New York City | Rockaway Beach |
| | *Rensselaer county* | |
| J. J. Patane | 102 Madison av., Albany | Rensselaer Heights |
| Boston & Maine Ry. Co | Boston, Mass | Hoosick Falls |
| A. E. Bonacker | Rensselaer | Rensselaer |
| William A. Bonacker | 472 Broadway, Rensselaer | Rensselaer |
| Estate of W. N. Onderdonk | Rensselaer | Rensselaer |
| Ulster Davis, Inc | 1 Second av., Rensselaer | Hudson river |
| Clemente Bros | Hoosick st., Troy | Troy |
| Whitehead Bros. (m) | 537 W. 27th st., New York City | Van Hoesen |
| James T. Murray | 1919 Sixth av., Troy | Troy |
| Richard S. Pickering | Spring av., Troy | Troy |
| Valley View S. & G. Co | R. D. 1, Troy | Troy |
| J. P. Williams Sons | R. D. 3, Troy | Troy |
| N. Y. Sand & Facing Co. (m) | 106 Grand av., Brooklyn | Van Hoesen |
| | *St Lawrence county* | |
| Charles Dillingham | Ogdensburg | Ogdensburg |
| Ogdensburg Brick & Sand Co | Ogdensburg | Ogdensburg |
| | *Saratoga county* | |
| Thomas F. Evers (m) | Waterford | Waterford |
| Paxson-Taggert, Inc. (m) | Luzerne & D sts., Philadelphia, Pa. | Elnora |
| Avery Jewett (m) | Jonesville | Clifton Park |
| Hynes Bros. (m) | P. O. Box 1018, Mechanicville | Mechanicville |
| Frank Poucher (m) | N. Third av., Mechanicville | Mechanicville |
| Tory Hill Sand & Gravel Co | Mechanicville | Mechanicville |
| Chas. E. Pettinos (m) | 25 Church st., New York City | Mechanicville |
| N. Y. Sand & Facing Co. (m) | 106 Grand av., Brooklyn | Round Lake, Stafford's Bridge, Mechanicville |
| Elton W. Stiles | Box 147, Saratoga Springs | Saratoga Springs |
| Albany Sand & Supply Co. (m) | Box 28, Albany | Burgoyne, Crescent, Elnora, Jonesville, Mechanicville, Schuylerville, Victory Mills, Stafford's Bridge |
| Sheridan D. Smith | South Glens Falls | South Glens Falls |
| Whitehead Bros. (m) | 537 W. 27th st., New York City | Ushers, Elnora, etc. |
| John Finnucci & Son | Waterford | Waterford |
| Corinth Sand Co | Corinth | Corinth |
| | *Schenectady county* | |
| Albany Sand & Supply Co. (m) | Box 28, Albany | Alplaus |
| Whitehead Bros. (m) | 537 W. 27th st., New York City | Scotia, Schenectady |
| Nicholas Palette | 32 Broad st., Amsterdam | Perth |
| W. W. Barclay | Pattersonville | Pattersonville |
| A. C. Ford (m) | 1095 Brierwood blvd, Schenectady | Schenectady |
| Boston & Maine Ry. Co | Boston, Mass | Scotia |
| Neil F. Ryan | Box 47, Schenectady | Scotia |
| J. H. Percy | R. D. 8, Scotia | Scotia |
| Scotia Sand & Gravel Co | Scotia | Scotia |
| Thomas F. Evers (m) | Waterford | South Schenectady |
| D. & H. Ry. Co | Albany | South Schenectady |
| Holland Sand Co., Inc | 103 Duane av., Schenectady | South Schenectady |
| Cushing Stone Co | 437 State st., Schenectady | Scotia |

| NAME | ADDRESS | LOCATION OF PIT |
|---|---|---|
| | *Schuyler county* | |
| John M. Roe | Watkins Glen | Watkins Glen |
| | *Seneca county* | |
| Thomas Masten | Seneca Falls | Seneca Falls |
| | *Steuben county* | |
| W. R. Stevens | 246 Williams st., Corning | Corning |
| Corning Stone Corp | Corning | Corning |
| Scudder & Jenks | 867 Lake st., Elmira | East Corning |
| Louis Beupre | Hornell | Hornell |
| | *Suffolk county* | |
| Henry Steers, Inc | 17 Battery pl., New York City | Northport |
| Montauk S. & G. Co | Montauk | Easthampton |
| Farmingdale S. & G. Co | P. O. box 11, Farmingdale | Farmingdale |
| Great Eastern Gravel Corp | Port Jefferson | Port Jefferson |
| Seaboard Sand & Gravel Corp | 26 Cortlandt st., New York City | Port Jefferson |
| Dr Leo F. Gieberich | 249 E. 86th st., New York City | Riverhead, Brookhaven |
| Central Park S. & G. Co | Farmingdale | Farmingdale |
| R. W. S. Corp | Huntington | Huntington |
| Heling Sand & Gravel Co | Lindenhurst | Lindenhurst |
| John Abrew | Bay Shore | Bay Shore |
| | *Tioga county* | |
| Delaware Lackawanna & Western R. R. Co. | 26 Exchange st., New York City | Nichols |
| Scranton Sand Co. (m) | Waverly | Nichols |
| William Hopkins | Barton | |
| | *Tompkins county* | |
| Reynolds S. & G. Co | Ithaca | Ithaca |
| E. M. Rumsey & Son | Ithaca | Ithaca |
| | *Ulster county* | |
| Ulster & Delaware R. R. Co | Kingston | Cold Brook |
| Robert Main & Co. (m) | Connelly | Connelly |
| Wilbur Sand Co | Kingston | Kingston |
| N. Y. Sand & Facing Co | 106 Grand av., Brooklyn | Marlboro |
| Rosoff Sand & Gravel Corp | 461 Eighth av., New York City | Marlboro, Milton |
| Chas. E. Pettinos (m) | 25 Church st., New York City | Kingston |
| N. Y. C. R. R. Co., Buffalo & East | N. Y. C. Bldg, New York City | Port Ewen |
| Adam S. Wolven | Saugerties | Saugerties |
| Dwyer Bros | Kingston | Kingston |
| | *Washington county* | |
| Mrs Alfred A. Smith | Smiths Basin | Smiths Basin |
| | *Wayne county* | |
| N. Y. C. R. R. Co., Buffalo & East | N. Y. C. Bldg, New York City | Palmyra |
| Sodus Bay Sand Co. (m) | Sodus Point | Sodus Point |
| | *Westchester county* | |
| Croton Sand & Gravel Co | Croton-on-Hudson | Croton-on-Hudson |
| N. Y. C. R. R. Co | N. Y. C. Bldg, New York City | Harmon |
| Triangle Sand Co | Box 126, Mamaroneck | Bedford |
| Nepperham Concrete Prod. Corp | Yonkers | Yonkers |
| Rochester Concrete Block & Sand Co | Port Chester | Port Chester |
| | *Wyoming county* | |
| Silver Springs Sand & Gravel Co | Silver Springs | Silver Springs |

## SAND-LIME BRICK

Sand-lime brick are made from a combination of calcium oxide, water and sand. The combination of these materials may be effected in various ways. The lime used is generally purchased and received at the plant either as lump, crushed or finely pulverized calcium oxide, or in the hydrated form as calcium hydroxide. If the lime is in the form of calcium oxide it must be hydrated. When the lime is in lump or crushed form it is hydrated before mixing with the sand, but if finely pulverized the hydrating may be done while mixing, or even after mixing, the lime and sand. Only 3 to 5 per cent of lime is required in the manufacture of the brick.

After preparation of the mixture the brick are molded under heavy pressure. They are then placed on cars and run into a steel hardening chamber or cylinder, where they are subjected to steam pressure of about 120 pounds a square inch for about 10 hours. The brick are then withdrawn and are ready for the market. The standard size for sand-lime brick is the same as for common brick, namely 2¼ x 3¼ x 8 inches. The United States Government specifications for common sand-lime brick permit variations from the standard sizes of one-eighth inch in breadth or depth and one-fourth inch in length. There are as yet no specifications of the American Society for Testing Materials to govern the size and permissible variations for sand-lime brick. The Sand-Lime Brick Association has, however, suggested that the permissible variations of the standard brick be plus or minus one-sixteenth inch in breadth and depth and plus or minus one-eighth inch in length.

The first plants in the State for the manufacture of sand-lime brick were erected about 25 years ago. During the past few years only three plants have reported production. These were the Buffalo Sandstone Brick Company, Buffalo; Rochester Composite Brick Company, Rochester; and the Paragon Plaster Company, Syracuse. The Paramount Brick Company, Brooklyn, planned to begin the manufacture of sand-lime brick in 1927, and this, no doubt, will materially increase the annual production in the State.

Production of sand-lime brick since 1917

| YEAR | PRODUCTION | VALUE |
|---|---|---|
| 1917 | 15 535 000 | $130 626 |
| 1918 | 6 776 000 | 79 515 |
| 1919 | 10 958 000 | 159 399 |
| 1920 | 11 294 000 | 176 114 |
| 1921 | a | a |
| 1922 | a | a |
| 1923 | 15 646 000 | 204 433 |
| 1924 | 16 529 000 | 220 851 |
| 1925 | 13 259 000 | 190 870 |
| 1926 | 11 510 000 | 158 283 |

a Less than three producers; figures can not be published.

## SLATE

The slate resources of the State are connected with the Taconic metamorphic region on the eastern border of the State. This region of sharply folded Cambrian and Ordovician strata includes much of the area east of the Hudson river and north of the Highlands, reaching over into western Connecticut, western Massachusetts and southwestern Vermont. It represents a mountain range that was uplifted in early Paleozoic time before the larger Appalachian disturbance occurred, and has a north-south axis in contrast with the northeast-southwest trend of the latter ranges. On the north the Taconic uplift is continued by the Green mountains, which extend northward into Canada.

The main slate belt lies along the western flank of the mountains and includes a strip a few miles wide extending from Washington county and the contiguous part of Vermont south through Rensselaer and Columbia counties into Dutchess county, east of Poughkeepsie. Although quarries have been opened at different places in the stretch of about 150 miles north and south, the most valuable deposits are in the northern section in Rutland county, Vermont, and Washington county, New York, which really form one district, of which the larger part lies in Vermont.

The slates are original clayey sediments or shales which have been hardened by heat and pressure incident to the folding of the rocks and which have developed thereby a secondary lamination or cleavage. The ingredients of the shale have been largely recrystallized into mica, chlorite, quartz, feldspar, magnetite, hematite and

other minerals in microscopic particles. In a similar manner the old calcareous sediments have been converted into marbles and crystalline limestones, and the sandstones into quartzite.

A remarkable feature of this district is the variety of colors exhibited by the slates. Red, gray, green, purple, black and variegated (green and purple mixed) slates are obtained in commercial quantities. As a rule the different colors occur in separate layers, but slight variations may be found in the same beds as they are followed in the quarry. The red slate has a localized distribution occurring only in the western part of the district in New York State. Most of the green slate also occurs in that section, while Vermont yields greenish gray, purple and variegated colors.

The best known product of the New York quarries is red slate of permanent nonstaining quality, that is scarcely to be duplicated elsewhere. The color is a hematite red, with a somewhat silky luster as seen by reflected light, the result apparently of an unusually large proportion of hematite which forms the matrix for the mica, quartz and other crystalline components. The slate has always found ready demand for roofing, at prices well above the average for such material, but the supplies are not unlimited and its production is attended with considerable uncertainty as only a small part of the quarried material yields cleavable slate. One of the striking features of the slate district is the large proportion of waste to the recovered product. Every quarry of roofing slate is evidenced on the surface by an accumulation of discarded material proportionate in size more or less, to the extent of the subsurface operations. It is not uncommon to throw as much as one-half of the quarried blocks on the dump. The utilization of this waste material is one of the most patent needs of the industry, and one that has received considerable attention at different times. Small outlets have been found for the discarded slate in connection with paint manufacture, as filler for rubber and asphalt, roofing and flooring materials, but the quantity available for such disposal is so large that little or no impression has been made thus far upon the supplies.

The use of slate in granular form for making prepared roofing has given rise in later years to an important branch of the industry. This is carried on quite apart from the quarrying of split slate and mill stock. It would appear from casual consideration that the making of granules offers a possible means of salvage of the waste material from other workings. But the crushing plants operate their own quarries which are selected with reference to the special

qualities required for granules, which are not altogether the same as those that enter into roofing slate. For the latter grade cleavage is quite essential, but in producing granules this tendency may lead to the development of thin splintery particles of insufficient body to withstand wear. No doubt a portion of the waste could be selected for crushing, but it is probably more economical to quarry the rock first-hand. The value of the crushed slate in late years has largely exceeded that of roofing and other kinds. Red slate is the principal variety used in the local crushing plants. The sizes employed in granules are mostly from 10 to 25 mesh. In the reduction process a large quantity of fines and dust is made, for which a limited sale is found as slate flour.

To the south of Washington county the slate belt has not been prospected to any extent, although small shipments have been made from a few places. Mather, in his Geology of the First District, (1843, p. 420) mentions the existence of quarries near Hoosick Corners; one being a mile north and another two miles northeast of that locality in the northeastern part of Hoosick township, Rensselaer county. He reports that blue and gray slates were obtained of excellent quality, but that difficulties of transportation and competition with Welsh slate prevented any extensive production.

Quarries were also opened at that time at New Lebanon, Columbia county, on the mountain east of the springs; one of the openings, known as the Rowley quarry, supplied considerable quantities of roofing material. At Hillsdale were other quarries that produced roofing material.

Slate was quarried at New Hamburg, Dutchess county, as late as 1898. The output included mill stock as well as roofing slate. The quality is reported similar to that of Welsh slate, with which it closely compares in color.

The resources of the central and southern parts of the belt invite investigation, as little is still known about the conditions over long stretches of the district. In the earlier days operations were hampered by the lack of good roads so that the expense of haulage to the Hudson river or to the few railroads that crossed the district was prohibitive. These difficulties have now been largely removed.

### Production

The slate output has shown a substantial gain in the past decade, which marks about the period of the large-scale manufacture of granules. The value of the various products in 1926 was $913,814

and $851,715 in 1925. The shipments of granules, including a relatively small quantity of slate flour, amounted to 113,890 short tons with a value of $732,783, as compared with 108,420 short tons with a value of $710,980 in the preceding year. The roofing slate sold was 11,093 squares ($177,455) as compared with 7650 squares ($108,420) in 1925. The high average value of this material, about $16 a square in 1926, is to be explained by the fact that most of the output consisted of red slate which commands better prices than other kinds.

The shippers of slate granules included the following firms: J. B. Preston Co., Granville; Staso Milling Co., Hampton; Sheldon Slate Products Co., Middle Granville; and Advance Industrial Supply Co., Granville.

The production of roofing slate is divided between a considerable number of individuals and small companies, as the business does not lend itself to large undertakings.

**Shipments of slate by New York quarries in 1925 and 1926**

| YEAR | ROOFING SLATE | | GRANULES AND FLOUR | | OTHER KINDS VALUE | TOTAL VALUE |
|---|---|---|---|---|---|---|
| | Squares | Value | Short tons | Value | | |
| 1925.... | 7 650 | $134 790 | 108 420 | $710 980 | $5 945 | $851 715 |
| 1926.... | 11 093 | 177 455 | 113 890 | 732 783 | 3 576 | 913 814 |

## STONE

Quarry materials are among the larger items in New York's mineral production. All the important commercial kinds of stone are found within the State, including granite and trap, sandstone, limestone and marble, so that nearly every requirement in the way of stone for engineering work and building construction could be supplied from local resources. There is, however, a large importation of building and ornamental stone from other states and even from foreign sources. Color and texture, as well as durability, are important considerations in the architectural uses of quarry materials, and they often lend preponderant weight to the selection of stone for such purposes.

The stone industry has undergone profound changes in the past quarter of a century. The use of cement, terra cotta and other forms of processed materials have curtailed the outlet for cut stone, so that this branch no longer occupies the prominent place it once had in the trade. Similarly, the market for flagstone, curbing and paving blocks in street work has fallen off appreciably, although they are still produced by local quarries. On the other hand, a tremendous impetus has been given to the crushed stone business, so that this is now much the largest branch. The changes have meant a real loss in industrial activities, notwithstanding the fact that the present production is larger in bulk than ever before. The preparation of cut stone for building and of flags and blocks requires the services of large numbers of skilled workmen, whereas a minimum of such labor is employed in crushing, which has been reduced nearly to a mechanical operation.

The statistics of stone production presented in the accompanying tables indicate a very active demand for most materials during 1925 and 1926. New records were made each year. The output in 1925 had a value of $13,626,032, showing an increase of about 20 per cent over the figures for the preceding year. In 1926 the value advanced to $14,730,267, representing a gain for the year of about 8 per cent. Since 1917 the industry has more than doubled its production in terms of value and probably also on the basis of tonnage.

Limestone is the principal variety quarried in the State. Its importance is conditioned not so much by the abundance of the material as by its allround adaptability to the purposes served by crushed stone. It is the common aggregate used in most engineering construction. The production has grown nearly threefold in the past decade.

Sandstone, the variety most affected by the changing methods of construction, shows evidence of a revived market, according to the reports of quarry operations in the past few years. This applies both to the trade in cut stone for building and in street work. The use of bluestone for curbing and crosswalks seems to have recovered a fair measure of its former importance.

Granite has shown a good gain, although fewer quarries have been in operation in 1925 and 1926 than formerly. The supplies of this stone are obtained from the Adirondacks, where monumental and building varieties are chiefly quarried, and from southeastern New York (Orange and Westchester counties) with building stone as the principal product. It is also quarried for crushed stone. Trap, a

dense heavy igneous rock, sometimes called black granite, is used altogether for crushed stone.

Marble ranks about on a parity with granite in production and has similar uses. Most of the monumental stone comes from St Lawrence county. Building marble is obtained in Westchester county. The trade was somewhat larger in 1925 and 1926 than in the preceding few years.

## Granite

The stone classed under this heading includes really a variety of materials not all of which can be called granite in the strict sense. The name has both a commercial and a specific usage. From the standpoint of the quarryman, it means almost any rock composed of silicate minerals that has a massive structure, in contrast with the bedded arrangement of sandstones. The stone is quarried in more or less cubic blocks, not in slabs, and as a rule has to be reduced and shaped by drilling and wedging.

In New York State true granites, which are massive igneous rocks composed largely of feldspar and quartz, are obtained as in the Mohegan quarries near Peekskill and in the quarries on the St Lawrence river. They are characterized by a light color, either of pink, gray or yellowish shade. Quarries have been opened in the interior of the Adirondacks on other kinds of stone like syenite, anorthosite and gabbro, which differ considerably from true granite in mineral composition although having the same massive habit and a similar origin. When selected with due care they are quite the equal of granite in strength and durability. They are employed for building and monumental work.

The production of granite in 1926, reported by 15 producers, was valued at $646,200. This value represents an increase of nearly $300,000 over that of 1925 and is the largest since statistics were first collected by this Department in 1904. The increase in value of granite is due to a larger output mainly of architectural building granite, reported by several operators. Among the large increases was that of the "Mohegan," or Peekskill granite from the quarries in Westchester county.

## Limestone and Lime

Limestones, including dolomites, have a wide distribution in the State, the only region that is not well supplied being that of the Catskill mountains and westward from there along the southern portion of the State, where the prevailing rocks are shales and

sandstones of Devonian age. They are also rather uncommon in the interior of the Adirondacks. The oldest and at the same time the most throughly crystalline limestones of the State are of Precambrian age, known as the Grenville strata and are associated with the gneisses and schists of the Adirondack region and the Highlands of southeastern New York. The Grenville limestones occur in patches and in more or less irregular belts which are often terminated and made discontinuous as a result of faulting. They afford most of the marbles of the State.

Limestones later than the Precambrian, except in some few cases where they have been subjected to faulting, occur in well-defined belts. The belts of limestone are more or less parallel, and some of them can be traced along their lines of outcrop for 300 or 400 miles. The lowest and oldest of these limestones belong to the Cambrian. They are found only on or close to the borders of the Adirondacks, in the Highlands area and in some sections intervening. The Ordovician limestones, which include the Beekmantown, Chazy, Lowville, Black River and Trenton formations, represent a group which are closely related in the sense that they form a more or less continuous stratigraphic series, there being no thick beds of shale or other kinds of sedimentary rock separating the various limestone formations. The Ordovician limestones have their best develópement in the Champlain, Hudson, Mohawk and Black river and St Lawrence valleys.

The Silurian limestones are separated from those of the Ordovician by many hundreds of feet of shales and sandstones. The lowest limestone of Silurian age is the Clinton, which occurs as a series of thin beds in the region south of Lake Ontario from a few miles east of Rochester to the Niagara river. South of the Clinton limestone and roughly parallel to it is the Lockport or Niagara dolomite, the upper part and some interbedded layers of which have been designated the Guelph dolomite. The Lockport extends from the Niagara river to Herkimer county where it thins to disappearance. One of the most important and at the same time the most extensive series of limestones consists of a number of individual formations which, on account of their close relations stratigraphically, may conveniently be designated as the "Helderberg" limestones. These limestones form a clearly defined belt that extends eastwardly from Buffalo to LeRoy, Geneva, just south of Syracuse, just north of Richfield Springs, through Cherry valley, into Schoharie and Albany counties. In Albany county the limestone belt turns to the south

and is found a short distance west of the Hudson river as far south as Kingston, where the belt takes a southwesterly direction and passes out of the State near Port Jervis. On the east side of the Hudson the Helderberg limestones occur as a single outlier near Hudson, and it is from this outlier that the limestone is obtained for the two portland cement plants operating there. The Helderberg limestones are the source of the material used in most of the portland cement plants in the State. The only two exceptions are the one at Glens Falls, which uses Trenton limestone, and the one at Portland point on Cayuga lake, where Tully limestone is employed.

The Tully limestone, which is restricted to central New York, is found some distance to the south of the Helderberg formations. The Tully is best developed in the region of Cayuga lake and in the counties on the east. No large or important quarries have been opened in the Tully other than the one supplying limestone for the cement plant at Portland point.

## Production

The value of limestone, including lime, produced in 1926 amounted to $11,972,510. Exclusive of lime the output consisted of 9,163,560 tons valued at $10,955,863, of which more than $9,000,000 was for crushed limestone. In addition to the limestone represented by the above figures, more than 2,400,000 tons of limestone were quarried for the manufacture of portland cement.

Lime produced in 1926 amounted to 107,326 tons valued at $1,016,647. This represents a small increase in production over 1925 and a slight decrease in value. Statistics of production do not include certain rather large amounts of lime made and consumed at their own plants by one or two companies. In these cases the value of the limestone used is reported under that material. Of the total amount of lime produced in 1926 about one-third, or 36,193 tons valued at $311,613, was reported as hydrated lime.

The bulk of the lime produced is used in the various chemical and manufacturing industries. Some of these use lime in such important amounts that the industries have been listed by name in the tables of production. In addition to the industries requiring large quantities of lime, there are many others which use small amounts of lime in various ways, and sales for such purposes are included under "other uses" in the tables. On account of construction activities during recent years, lime used for building purposes has been a large item in lime production. Agricultural

lime, used as a fertilizer, forms but a small item and its use has actually decreased during recent years. The decrease in the use of lime as a fertilizer can be in part attributed to a more extended use of the less expensive ground or pulverized limestone. In 1926 lime reported sold for fertilizer amounted to but 3419 tons valued at $28,903. The sales of ground agricultural limestone during the same year amounted to 82,830 tons valued at $241,007. The average price for fertilizer lime was $8.45 a ton and for ground limestone $2.91 a ton. At present the number of lime-producing plants in the State is small when compared to the number that existed some years ago. Formerly there were many lime kilns widely distributed among the limestone sections of the State. The chief product of the early burners was lime for use in mortar and for agriculture. With the development of the cement industry and the use of cement as a substitute for lime in building operations, the natural growth of lime production for mortar purposes has been greatly retarded.

The following list contains the names of producers of lime in the State together with their addresses and locations of plants:

Chazy Marble Lime Co., Chazy, Clinton county.
Kelly Island Lime & Transport Co., Cleveland, Ohio. Plants at Dover Plains, Dutchess county, and Buffalo, Erie county.
Willard A. Kegg, Cranberry Creek, Fulton county.
Merl Haines, Mayfield, Fulton county.
U. S. Gypsum Co., Chicago, Illinois. Plant at Oakfield, Genesee county.
Basic Refractories Corp., York, Pa. Plant at Natural Bridge in Jefferson and Lewis counties.
Mohawk Limestone Products Co., Mohawk, N. Y. Plant at Jordanville, Herkimer county.
George M. Fisher, Seneca Falls, Seneca county.
H. L. Devoe, Accord, Ulster county.
A. J. Snyder & Co., Rosendale, Ulster county.
Finch, Pruyn & Co., Inc., Glens Falls, Warren county.
The F. W. Wait Lime Co., Glens Falls, Warren county.
Keenan Lime Co., Smiths Basin, Washington county.

In addition to the above, the Union Carbide Co., Niagara Falls, and the Solvay Process Co., Syracuse, produce lime for their own use.

## Marble

Such portion of the limestone resources that is utilized more especially for its ornamental qualities is considered under this head. Marble is a trade name that has been applied to almost any soft stone capable of a lustrous finish. In the limestones the luster and ornamental appearance depend mainly upon the development of a crystalline texture which results from metamorphic processes, and

consequently most of the marbles of the State are associated with the older formations which have been involved in mountain uplifts such as occur in the Adirondacks and the southeastern Highlands. They belong to the Precambrian and early Paleozoic periods.

The Adirondack region has many areas of crystalline limestones, but the most important are in the western section in Jefferson, St Lawrence and Lewis counties. Marble quarries have been opened in several localities, of which Gouverneur is best known to the trade. The marble from that place has been utilized extensively for monumental work and in buildings throughout the eastern part of the country. It is a crystalline, medium-textured stone of light gray, mottled gray and white, or solid blue-gray color, capable of a high polish. It has a high per cent of carbonates (95 per cent or more) so that it is well adapted also for lime burning and furnace flux. Canton, Natural Bridge and Harrisville are other places in this region where marble has been quarried. Crushed marble for stucco and artificial stone is a later product of the district.

The marbles of southeastern New York are found in Westchester, Dutchess and Columbia counties, on the east side of the Hudson river. They occur in belts which follow the north-south valleys. They are commonly white to light gray color, well adapted for building stone, of which many examples are to be seen in the commercial structures and churches of New York City. The marbles are mostly dolomites and are interfolded with gneisses and schists. The leading quarries are at Dover, Westchester county, but formerly Tuckahoe, Pleasantville and Dover Plains shipped building marble. The manufacture of artificially molded stone has been carried on in connection with some of the quarries.

Besides the crystalline limestones some varieties of the bedded granular limestones that occur in the unmetamorphosed Paleozoic formations have ornamental qualities that class them in the trade as marbles. The black Trenton limestone of Glens Falls is of this type. It polishes to a uniform black surface and has been employed for floor tiles, mantles and interior work. The Chazy limestone from Bluff Point, south of Plattsburg, yields a fossil marble characterized by red and pink fragments of crinoids in a gray crystalline ground mass. It is sold for interior decorative works.

The reported value of the marble quarried in 1925 was $510,900, or about the same as in the preceding year. In 1926 the output had a value of $673,322.

## Sandstone

The sandstones of the State have the largest areal distribution of the sedimentary rocks. In number of quarries operated and value of product, sandstone ranks next to limestone. The products from quarries located in the Devonian formations are usually classified under the term "bluestone." While blue is the prevailing color of the Devonian sandstones, there are some variations from this color and in some sections other shades, such as red and brown, are found. The quarries of bluestone are located in the Catskill and Helderberg mountain areas and in the continuation from these regions of the Hamilton, Oneonta, Portage and Chemung sandstone formations, which collectively form the major part of the Allegany plateau of central and southwestern New York. Outside of the region producing bluestone, sandstones are usually designated by the name of the formation in which the quarries are located. Among these are the Medina, Potsdam, Hudson River and Clinton formations. Of these, the quarries in the Medina formation are the only ones to produce sandstone in substantial amounts at the present time.

In 1926 the total production in the State of all kinds of sandstone was valued at $1,171,885. This represents a decrease in value of production as reported for 1925. Of the total value of sandstone, bluestone was credited with $728,193. Sandstone outside of the bluestone district was valued at $443,692, of which Orleans county was credited with $368,558 and other localities with $75,134.

The value of sandstone reported as building stone amounted to $251,658. Almost the entire production was from the bluestone region, particularly Chenango and Wyoming counties. The largest individual item of sandstone was curbing, with a value of $671,439. Of this amount $357,047 was for bluestone and $314,392 for sandstone. Flagging was valued at $96,155. Almost the entire output came from the bluestone district. Sandstone for paving amounted to $54,246, all of which was produced in Orleans county.

## Trap

The term "trap" refers to the dark-colored, fine-grained igneous rocks like diabase and basalt that occur in intrusive sheets and dikes. The commercial value of trap lies chiefly in the excellent quality of the crushed stone it yields. The largest body of trap rock in the State, and the only one in which large quarries have been opened, is that which forms the Palisades of the Hudson, south of Haverstraw. While numerous small bodies of trap occur, mostly as

relatively small dikes in the Adirondacks and the Highlands of southeastern New York, few are of such size or favorably enough located for good quarry sites. Of the more important larger dikes, one is at Little Falls, Herkimer county, and the other in the town of Greenfield, Saratoga county. A quarry producing crushed stone has been operated at the latter locality.

The marked decrease in the production of trap rock or diabase during recent years is due almost entirely to the closing of the large quarries along the face of the Hudson Palisades, which have been taken over by the State for the Palisades Interstate Park. Present operations are conducted outside of the park at some distance back from the Hudson and also near the northern end of the trap formation.

**Production of stone in New York since 1917**

| YEAR | GRANITE | LIMESTONE | MARBLE | SANDSTONE | TRAP | TOTAL |
|---|---|---|---|---|---|---|
| 1917 | $182 515 | $4 406 729 | $249 180 | $760 582 | $684 550 | $6 283 556 |
| 1918 | 191 551 | 4 832 348 | 135 756 | 325 351 | 621 750 | 6 106 756 |
| 1919 | 94 820 | 5 538 581 | 250 244 | 384 516 | 619 799 | *a*6 988 735 |
| 1920 | 204 491 | 7 151 151 | 220 773 | 547 424 | 794 653 | *a*9 061 707 |
| 1921 | 232 190 | 7 748 530 | 255 530 | 901 915 | 201 677 | *a*9 464 630 |
| 1922 | 370 471 | 7 469 370 | 336 956 | 1 372 429 | 151 977 | *a*9 756 674 |
| 1923 | 204 578 | 8 501 621 | 412 875 | 1 259 257 | *b*269 730 | 10 648 061 |
| 1924 | 211 766 | 9 461 774 | 532 358 | 1 529 590 | *b*238 125 | 11 973 613 |
| 1925 | 349 443 | 11 180 400 | 510 900 | 1 348 455 | *b*236 834 | 13 626 032 |
| 1926 | 646 200 | 11 972 510 | 673 322 | 1 171 885 | *b*266 350 | 14 730 267 |
| Total | $2 688 025 | $78 263 014 | $3 577 886 | $9 601 404 | $4 085 445 | $98 640 031 |

*a* Includes value of miscellaneous stone for which no separate column is given.
*b* Includes value of miscellaneous stone.

**Production of stone according to use in 1925**

| KIND | BUILDING STONE | MONUMENTAL | CURBING AND FLAGGING | CRUSHED STONE | ALL OTHER | TOTAL VALUE |
|---|---|---|---|---|---|---|
| Granite | $152 722 | $36 105 | ........ | $76 792 | $83 824 | $349 443 |
| Limestone | 129 954 | ........ | ........ | 8 463 070 | *c* 2 587 376 | 11 180 400 |
| Marble | 167 226 | *a* | ........ | .......... | 343 674 | 510 900 |
| Sandstone | 426 082 | ........ | 800 234 | 122 139 | .......... | 1 348 455 |
| Trap | ........ | ........ | ........ | *b*236 834 | .......... | 236 834 |
| Total | $875 984 | $36 105 | $800 234 | $8 898 835 | $3 014 874 | $13 626 032 |

*a* Included in building stone.
*b* Includes value of miscellaneous stone.
*c* Includes value of lime but not value of limestone used in cement manufacture.

## Production of stone according to use in 1926

| KIND | BUILDING STONE | MONUMENTAL | CURBING AND FLAGGING | CRUSHED STONE | ALL OTHER | TOTAL VALUE |
|---|---|---|---|---|---|---|
| Granite | $440 061 | $51 952 | *a* | $73 261 | $80 926 | $646 200 |
| Limestone | 138 740 | ........ | ........ | 9 223 427 | *c* 2 610 343 | 11 972 510 |
| Marble | 282 493 | *b* | ........ | .......... | 390 829 | 673 322 |
| Sandstone | 251 658 | ........ | 821 870 | 87 504 | 10 853 | 1 171 885 |
| Trap | ........ | ........ | ........ | *d* 266 350 | .......... | 266 350 |
| Total | $1 112 952 | $51 952 | $821 870 | $9 650 542 | $3 092 951 | $14 730 267 |

*a* Included in all other.
*b* Included in building stone.
*c* Includes value of lime but not value of limestone used in cement manufacture.
*d* Includes value of miscellaneous stone.

## Production of lime in New York since 1917

| YEAR | PRODUCTION IN SHORT TONS | VALUE |
|---|---|---|
| 1917 | 108 788 | $892 855 |
| 1918 | 87 127 | 913 366 |
| 1919 | 126 404 | 1 131 860 |
| 1920 | 92 357 | 1 047 261 |
| 1921 | 67 685 | 759 299 |
| 1922 | 96 320 | 957 079 |
| 1923 | 100 862 | 1 037 737 |
| 1924 | 98 592 | 991 799 |
| 1925 | 104 829 | 1 030 960 |
| 1926 | 107 326 | 1 016 647 |
| Total | 990 290 | $9 778 863 |

## Production of lime in New York in 1925–26

| KINDS | 1925 | | 1926 | |
|---|---|---|---|---|
| | Short tons | Value | Short tons | Value |
| Building | 35 036 | $306 756 | 33 606 | $273 095 |
| Chemical works | 14 943 | 158 512 | 17 685 | 179 962 |
| Paper mills | 18 771 | 194 161 | 17 677 | 179 845 |
| Tanneries | 3 101 | 43 686 | 4 417 | 55 024 |
| Fertilizers | 3 902 | 33 696 | 3 419 | 28 903 |
| Metallurgy | 12 764 | 140 766 | 13 283 | 140 517 |
| Other uses: Glass works, Sugar factories, Refractories | 16 312 | 153 383 | 17 239 | 159 301 |
| **Total** | 104 829 | $1 030 960 | 107 326 | $1 016 647 |

## TALC

The talc mines of northern New York reported favorable market conditions both in 1925 and 1926, although the trade at large was rather depressed and many producers were handicapped by a slackened demand for their products. The special grades which have been made by the local industry for many years have become well established in the trade, with such diversified outlets that a fairly steady market is maintained except in periods of general depression. The last depression of this kind occurred in 1920-21, when the output was reduced to about one-half of the normal figure. The industry recovered rapidly and since 1922 has not only regained the lost ground but has shown a tendency to enlarge its scope beyond the former proportions.

The production in 1925 amounted to 85,109 short tons with a value of $993,913 and in 1926 to 83,231 tons valued at $1,030,075. These are nearly record figures. The tonnages have been exceeded only once in the history of the trade by the total of 93,236 tons reported for 1916. The average values of $11.66 a ton in 1925 and of $12.40 a ton in 1926 are somewhat below those for the preceding two or three years but still above the average over a longer term.

The first shipments of ground talc from the Gouverneur district were made about 50 years ago. The material was first ground by millstones like those used in cereal mills. In the period from 1880 on, the industry rapidly progressed and special equipment was procured for treating the talc. The output from the beginning down to 1926, including the small proportion reported from the mine in Lewis county, has been a little more than 2,400,000 tons with a value in excess of $24,000,000.

Mining in the Gouverneur district is carried on by the International Pulp Co. and the W. H. Loomis Talc Corp. At Natural Bridge, Lewis county, the Carbola Chemical Co. is the sole producer.

### Gouverneur District

The talc deposits occur in a belt of crystalline limestone that lies to the east and southeast of Gouverneur in the Adirondack foothills. All of the formations, except the glacial deposits on the surface and a few scattered areas of Potsdam sandstone, are of Precambrian age and for the most part belong to the series of ancient sediments which are known collectively as the Grenville series. The district extends from Sylvia lake on the southwest to a little beyond the

village of Edwards on the northeast, a distance of 12 miles. The width, as indicated by the outcrop of the limestone, is from one-half mile to two miles.

Altogether, nearly 20 mines and prospect shafts have been opened in the district and contributed to the output at one time or another. A dozen mines, perhaps, have yielded substantial quantities of rock. For many years the industry was split up into a number of individual enterprises, each operating in a small way and producing material of varied quality. Competition gradually brought about a consolidation of the producing interests and the centering of production about a few properties which combined the most economical facilities for mining, milling and shipment. In later years the district has had a railroad outlet through a branch line running from Gouverneur to Edwards. The mills are located along the line which follows the Oswegatchie river for most of the distance. The river provides many power locations that have been put to use in grinding the talc.

The International Pulp Co. has the largest holdings in the district, having taken over many of the early mines and mills. Its operations are now confined to a few properties which are equipped for meeting the production demands that once required the facilities of a larger number of units. The principal mine workings are at Talcville where there is a series of openings on a well-developed talc zone along the contact with limestone and granite. This zone extends for more than two miles on the trend of the limestone and in places carries several seams of talc in parallel arrangement, overlapping or succeeding each other end-to-end along the strike. Among the more important producers in this part have been shafts Nos. 2½, 3, 4 and 5 in the first mile northeast of Talcville and the mines formerly worked by the United States Talc Co. and the Uniform Fibrous Talc Co. in the adjoining southwestern part. The company derives a portion of its rock supply from deposits in the southwestern area, where the Balmat mine near Sylvia lake and the Wight mine south of Fowler have been among the larger producers.

The W. H. Loomis Talc Corp. began operations in the district in 1919, when it took over the Arnold mine near Fowler. A mill was erected at Emeryville on the railroad and river, about three miles distant by road, over which the talc is hauled. A second mill was later built to the west of Emeryville. The Arnold is one of the older producers and is located on a talc zone near the southern margin of the limestone belt, here bordered by gabbro gneiss of earlier age

than the granite. The zone carries several seams of talc separated by varying thicknesses of schist and is worked as a unit, leaving most of the waste rock in pillars or as fill in the exhausted stopes. The mining is carried on through an incline, which starts at 55° and steepens gradually with depth, with eight levels opening from it, that extend along the course of the seams for varying distances. The talc is found in both fibrous and foliated forms, a condition more common on the southwest than elsewhere in the district. Exploratory work has been carried on also in the Johnson mine, just east of Fowler, but no regular shipments have been made as yet from this property. The shaft formerly bottomed at 85 feet on the dip of the seam, was extended to 190 feet so as to prospect the body at greater depth and determine the quantity and quality of the material available. The mine has supplied a small production in years past.

### Natural Bridge

The talc mine of the Carbola Chemical Co. is about one and one-half miles northeast of Natural Bridge, Jefferson county, just across the boundary in Lewis county. The locality is some 12 miles south of the Sylvia lake section of the Gouverneur district and in a separate body of the Grenville limestone, one of a series of small limestone outcrops that follow each other in a northeast-southwest direction and that together form a parallel, but much broken belt to the Sylvia lake-Edwards area.

The talc occurrence shows features quite unlike those found in the other district. The contact between the deposit and limestone is quite irregular instead of being defined by smooth nearly plane surfaces that conform to the dip and strike of the country rocks. Large inclusions or bowlders of limestone occur within the deposit, and secondary quartz and serpentine also occur in places. The color of the talc is grayish as seen in hand specimens. Its texture is granular to massive, but never distinctly fibrous or foliated like the Gouverneur mineral. The mine openings consist of an inclined shaft which starts at an angle of 57° and steepens at 45 feet from the surface to 68° and a series of levels at 100, 147 and 202 feet vertical depth. The first level has yielded most of the output up to the present time. The rock is prepared in a mill situated on the property.

## Trade Conditions

The markets for New York talc are mainly in the manufacture of such materials as paper, rubber, paint, prepared roofing, foundry facings and as an ingredient of cement and gypsum plasters. The Gouverneur talc has a lighter color than most of the domestic talc that is supplied in large quantity, and hence finds favor as a filler of white papers, which has always been an important outlet. The quality of softness and smooth feel in which it is naturally somewhat deficient has been improved by the introduction of better methods of mill treatment, namely, by finer grinding and by using air flotation to grade the pulverized materials. The principal demands now are for extremely fine sizes, 200 mesh and smaller. These are obtainable by tube milling which is standard practice, followed by air separation to secure the finest products which are supplied in bulk quantities to pass a testing screen of 325 mesh. The paint industry is also an important consumer. Formerly talc was considered as an adulterant, when mixed with paint, but later experiments have tended to show that it gives certain valuable qualities which warrant its employment with lead and zinc pigments. In prepared paints its presence operates to keep the heavier ingredients in suspension and it also adds strength to the paint coat when applied to surfaces. The popular term and trade name for the local talc employed in paint manufacture is "asbestine," which alludes perhaps to the fibrous nature of the material, in which it somewhat resembles asbestos. In other respects the name has no significance, for asbestos possesses quite different chemical and physical attributes. As an ingredient of cements and mortars talc functions as an inert filler, rendering the set materials less permeable to water and decreasing the shrinkage.

Production of talc in New York since 1919

| YEAR | SHORT TONS | VALUE |
|---|---|---|
| 1919 | 62 495 | $750 765 |
| 1920 | 68 168 | 977 228 |
| 1921 | 37 489 | 464 645 |
| 1922 | 71 470 | 1 116 914 |
| 1923 | 71 304 | 1 079 322 |
| 1924 | 78 340 | 1 162 488 |
| 1925 | 85 109 | 993 913 |
| 1926 | 83 231 | 1 030 075 |
| Total | 557 606 | $7 575 350 |

## ZINC

The zinc ores near Edwards village, St Lawrence county, have contributed the greater part of the production of this metal credited to New York sources. They were actively worked in 1925 and 1926, with about the usual output. Altogether, the ore hoisted from the Edwards mines since the beginning of operations in 1915, has amounted to 536,304 short tons, of which the recoverable zinc is estimated at 56,418 tons, a yield of a little more than 10 per cent. An additional quantity of metal remains in the tailings from the mill operations, since the average content of the crude ore is about 17 per cent zinc. A good part of this will be recovered by retreatment, as indicated by recent experimental operations in that direction.

The Edwards mines are on the Brown, White and Brodie farms, just outside the village limits. Ore was first found there in 1903, but actual production and shipments did not begin until 1915. The Northern Ore Co. operated the properties until 1923 when the New York Zinc Co. succeeded to ownership. In 1926 the St Joseph Lead Co. took over the mines.

The workings consist of four shafts, two inclines of about 400 feet and 800 feet in length on an angle of 45°, and two vertical shafts. The inclines follow the dip of the ore to the northwest. The vertical openings are located on the hanging wall and tap the continuation of the deposits at about 960 and 1560 feet respectively. The underground workings extend over several miles, but cover a rather narrow band of the ore formation to which exploration so far has been confined. Seven different deposits have been found within the property, some without any outcrop; they consist of irregular bodies and lenses of mixed blende and pyrite in zonal and overlapping arrangement, the individual bodies measuring up to 400 feet long and 75 feet thick in extreme dimensions. The reserves of unmined ore are not less than the actual tonnage already mined.

Mill treatment of the Edwards ore consists of crushing and grading according to size, the treatment of the coarse fractions in Harz jigs and the fines by shaking tables. A crude concentrate is recovered that contains about 30 per cent zinc and most of the pyrite in the ore. This is then passed over tables within a strong magnetic field (Weatherby concentrators), where the nonmagnetic pyrite and the slightly magnetic blende are separated. The blende crystals contain about 5 per cent iron as ferrous sulphide, which is the source of their magnetic property. The pyrite produced is retreated and sold for its sulphur content whenever the market

warrants. Some 6 or 7 per cent of zinc remains in the mill discharge, and the large accumulation of tailings with their zinc content is a reserve out of which further recoveries no doubt will be made in the future. This percentage is really larger than that of the run-of-mine ores in many districts.

## Other Zinc Deposits Near Edwards

The belt of crystalline limestones which carries the zinc blende has a length of about 12 miles and contains a number of showings on the surface, of which only those near Edwards have been extensively developed and proved to be of economic significance. Some work was performed in the period 1918–22 at Hyatt, near Talcville, where about three feet of rich blende outcropped at the surface. The Hyatt Ore Corp. leased the property and put down an incline following the dip of the body to a depth of 425 feet. Ore was taken from four levels, of which the first and longest level at 150 feet depth was also used to prospect the ground to the southwest and was extended a distance of 750 feet. The ore raised, amounting to several thousand tons, was treated in a small mill on the property, now dismantled. Good ore showings are still to be seen on the surface beyond the limits of the tested ground. The position of the ore corresponds closely to the zone in which the Edwards deposits occur; that is, the occurrence is on the hanging side of the limestone near its contact with granitized Grenville gneiss.

On the southwestern end of the belt in the vicinity of Sylvia lake are the Balmat and Streeter properties which have good surface indications. They have been explored in a very limited way. There are numerous other more or less promising showings, of which a list will be found in Geology of the Gouverneur Quadrangle, Cushing & Newland, ('25, p. 90–109).

## Geological Studies

The Edwards zinc ores belong to a restricted geological type and have attracted a good deal of interest on that account. From the standpoint of their physical and chemical relations and origin, the most searching investigation is that of C. H. Smyth jr ('17) who finds the closest resemblance to certain blende occurrences in southern Norway. The study by Smyth indicates the ores to be in the nature of replacement deposits formed in limestone as the result of the intrusion of granite. The mineralizing agency was the hot

magmatic waters released by the granite in the cooling stages while the limestones were deeply buried. It appears probable that the source of the zinc is to be traced to the granite itself, where it existed originally as sulphide but was transported in the form of chloride after reaction with hydrochloric acid of the granite magma. In contact with the limestones (actually dolomite) the zinc was thrown out of solution by a double reaction whereby the zinc was fixed as sulphide and the lime and magnesia carbonates were changed to chloride compounds. The limestone, in other words, served as a precipitant and itself was dissolved to make room for the ore. This may be designated the replacement method of origin.

This general explanation is adopted in the report on the Edwards district by Newland ('17) and in the paper of Wandke and Wade ('23), descriptive of the deposits in the vicinity of Edwards. Spurr ('24) refers the origin of the zinc bodies to igneous injection, similar in principle to the injection of a dike of igneous rock from below into an overlying rock mass. The source of the ores is still to be found in the granite, but instead of being carried into the limestone in thin solution, from which the zinc is thrown out by chemical reaction, the metallic sulphides are regarded as essentially magmas of themselves formed by a process of differentiation and forced into their present position under pressure. This view conceivably may be applicable to the rich sulphides that occur in some places, but for the most part the deposits consist of disseminated sulphides in the limestone or of bodies that decrease in sulphide content from center to borders where they shade off into the unmineralized rock. Such occurrences are more likely the work of waters carrying small amounts of dissolved metals and with capacity for penetrating into small openings, as well as for the solution of the limestone so as to provide room for the deposition of the new minerals. That solution has taken place is evidenced by the presence of clay partings between the ore and the walls in some of the bodies, the clay being a residue of the less soluble materials of the limestone.

The study of the origin of the deposits has its practical side as well as its interest arising from the relative rarity of zinc ores in the early Precambrian formations. The derivation of the zinc from magmatic sources points to its probable continuity to depths beyond those attained by the more usual types of occurrences. The deposits bear no relation to the existing surface conditions. So long as the limestone persists without any marked changes of character there

is possibility of the presence of ore. The later mining developments seem to bear out these conclusions, for there is no diminution in the magnitude of the resources as depth is gained, but rather an increase.

## Shawangunk District

Veins carrying galena, blende and some chalcopyrite occur in the Shawangunk conglomerate which forms the crest and western face of the Shawangunk ridge or mountain between High Falls, Ulster County and Port Jervis on the Delaware river. The veins occupy fissures, brecciated zones and bedding planes in the conglomerate, the larger bodies occurring in fractures formed by differential movement when the mountain was uplifted at the close of Carboniforous time. The size of the veins is determined by the extent of the fracturing. There are no igneous intrusions in the vicinity, and the ores were deposited probably under shallow conditions, as indicated by the well-rounded crystal forms exhibited by the several minerals and the frequent occurrence of vugs or cavities lined with such crystals.

The district has supplied small quantities of lead and zinc ores from intermittent mining operations. These date back for some deposits to the early part of the 19th century. The Ellenville deposit was opened about 1820 and one near Wurtsboro was in operation in 1838. Lead was the element sought at that time, and no use was made of the blende which in most occurrences is the more abundant mineral. No record has been kept of the output from the various deposits, but it could hardly have exceeded 15,000 or 20,000 tons of concentrates.

The last active operations in the district were carried on between 1915 and 1918. At this time the old workings at Ellenville, Guymard and Summitville were pumped out and used to prospect the deposits. At Summitville a small mill was erected by the St Nicholas Zinc Co., and was operated for a year or so on ore taken from the upper part of the vein. No attempt, so far as is known, has been made anywhere to test the continuity of the deposits in depth.

### Production of zinc in New York since 1915

| YEAR | ZINC ORE IN SHORT TONS | ZINC IN SHORT TONS | VALUE |
|---|---|---|---|
| 1915 | 14 398 | 2 455 | $649 593 |
| 1916 | 40 800 | 4 507 | 1 154 152 |
| 1917 | 47 961 | 5 192 | 1 059 186 |
| 1918 | 40 850 | 3 776 | 687 230 |
| 1919 | 51 411 | 5 120 | 747 666 |
| 1920 | 53 780 | 5 654 | 915 948 |
| 1921 | 39 940 | 1 572 | 157 200 |
| 1922 | 53 400 | *a* 4 816 | 549 024 |
| 1923 | 63 660 | 8 463 | 1 150 968 |
| 1924 | 40 350 | 4 664 | 606 320 |
| 1925 | 47 254 | 5 158 | 784 016 |
| 1926 | 42 500 | 5 041 | 756 150 |
| Total | 536 304 | 56 418 | $9 217 453 |

*a* Includes some zinc from ore treated in 1921.

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## REVISION OF THE SPIDER GENERA ERIGONE, EPERIGONE AND CATABRITHORAX (ERIGONEAE)

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AND

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CONTENTS

# REVISION OF THE SPIDER GENERA ERIGONE, EPERIGONE AND CATABRITHORAX (ERIGONEAE)

BY

C. R. Crosby and Sherman C. Bishop

## INTRODUCTION

In the course of our studies of the spider fauna of New York State we have found it necessary to revise many of the genera in order that we may be sure of the identity of the several forms and the extent of their range. In this paper we have revised those genera of the Erigoneae which form a natural group distinguished from other members of the series by the form of the embolic division of the genital bulb of the palpus of the male.

The preparation of the drawings was made possible by a grant from the Heckscher Research Foundation at Cornell University. The drawings have been made by Albert W. Force, K. L. Washburn, W. J. Schoonmaker, Sara Sturman, Ksenia Polevitzky and Irene Polevitzky.

The greater part of the material studied is in the collections of the New York State Museum and of Cornell University. The types of the species described by Emerton, Banks, and Chamberlin were studied in the Museum of Comparative Zoology at Cambridge. The American Museum of Natural History in New York City assisted by the loan of many specimens. We are also indebted to J. H. Emerton for many specimens and to Dr R. V. Chamberlin and Professor William M. Barrows for much useful material. Richard Hancock of Birmingham, England, has been especially helpful in securing specimens of rare species for comparison. Dr A. Randall Jackson of Chester, England, was kind enough to examine certain of Cambridge's types at Oxford. We are also indebted to Kai L. Henriksen of the University Zoological Musuem at Copenhagen for the loan of specimens.

The great group of spiders known as the Erigoneae may be divided into two sections based on the structure of the embolic division of the palpal organ of the male. In one section, represented by Erigone and its allies, the embolic division consists of a more or less elongate central body, for which we propose the name *scaphium*, (figure 3, *S*); it is usually armed with three teeth, the *anterior* (*C*),

*median* (*B*), and *posterior* (*A*). In some forms either the median or posterior tooth may be lacking. The opening of the ejaculatory duct is usually on a minute tubercle near the base of the anterior tooth. On the mesal side of the scaphium there is a wide thin projection which is usually turned downward and bears a rather large process directed forward, the *mesal* tooth. In the other section, comprising the rest of the Erigoneae, the embolic division is not of this form and is usually provided with a " tailpiece," often very long and spirally curved as in Ceraticelus, Ceratinopsis, Grammonota etc., or much shorter and flat as in Oedothorax etc. In some cases the ejaculatory duct opens on a minute tubercule but usually the opening is near the tip of a stylelike process or at the end of a long, slender, curved or coiled whiplike embolus.

This paper deals with the spiders belonging to the former section, Erigone and related genera.

*Erigone atra*, one of the more common and widely distributed species, has recently attracted attention and become of economic importance in certain greenhouses. Specimens taken in December 1927 at Rochester, N. Y., were causing annoyance by spinning webs on roses.

### Key to Genera, Males

1 Patella of male palpus with a terminal ventral process. A lateral row of teeth on face of chelicerae.............................. *Erigone*

Patella of male palpus without a terminal ventral process. Usually without a lateral row of teeth on face of chelicerae.................. 2

2 Embolic division of palpal organ with the posterior tooth greatly prolonged, usually hairy or armed with minute flattened teeth *Catabrithorax*

Embolic division with the posterior tooth of normal size... *Eperigone*

### **Erigone** Audouin

Egypt Hist. Nat. 1, pt 4, p. 115. 1825–27.
Type: *E. vagans* Audouin

The more typical species of Erigone are easily recognized by the great development of spines, especially on the margin of the cephalothorax, on the anterior face of the chelicerae and on the under side of the femur of the male palpus. This armature of spines is carried to its highest development in *psychophila*. The patella of the male palpus is armed at the tip with a large process which extends downward at right angles. The tip of the tibia of the male palpus is deeply excavated dorsally to form a deep pit. In one group of species (*psychrophila* etc.) this pit is confined to the outer half of the tibia; in the other it extends all the way across the tip (*atra*).

There are a considerable number of species, especially in America' which are related to Erigone but in which the more striking characters of that genus have faded out one by one and in varying degrees in the different forms. Many of these species have been placed in Tmeticus by Emerton and Banks but in the type of that genus, *T. affinis* Blackwall, specimens of which have been kindly sent us by Dr A. Randall Jackson, the embolic division consists of a thin, oblong, nearly flat plate ending anteriorly in two points. The ejaculatory duct opens at the tip of the mesal one. The tibia is squarely truncate at tip and is armed dorso-laterally with a pair of small teeth. Tmeticus does not belong in the same section with Erigone and its allies. Through the kindness of Richard Hancock we have also had the opportunity to study the type of *Anglia hancockii* Smith, a synonym of *Tmeticus affinis* Blackwall.

Mermessus Cambridge, type *M. dentiger* Cambr. (not *Erigone dentigera* Cambr.) from Guatemala seems to differ from Erigone in the absence of spines on the margin of the cephalothorax and femur of palpus. The lateral row of teeth is well developed on the face of the chelicerae. The figure does not show a ventral process on the patella but in the description we find, " beneath the fore extremity of the short somewhat clavate cubital joint [patella] is a short prominence or point, or rudimentary spur." On the whole it seems closely related to *E. dentimandibulata* Keys. We would reunite it with Erigone.

Due to the practice of the older authors of including in Erigone all species belonging to the modern group of the Erigoneae our catalogs contain a large number of species under this name which it is impossible to place generically without an examination of the type specimens. In this paper we have confined our attention to those species which are manifestly related to Erigone in the restricted sense.

## Notes on Species

*Erigone albescens* Banks. Can. Ent. 30:187. 1898. From the District of Columbia. The types are all females. It is not an Erigone.

*Erigone coloradensis* Keyserling. Spinn. Amer. Therid. 2: 168, pl. 17, fig. 230. 1886. From Colorado. We have three species from Colorado to any one of which the description and figures of this species would apply about as well as to another.

*Erigone clarksvillense* Petrunkevitch. N. Y. Ent. Soc. Jour. 33:172, pl. 8, fig. 3, 4. 1925. Described from female only. It is *Eperigone tridentata* Emerton.

*Erigone dentimandibulata* Keyserling. Spinn. Amer. Therid. 2:163, pl. 16, fig. 226. 1886. Peru and Colombia. This is a true Erigone but the ventral process on the patella of the male palpus is short and conical and the abdomen is ornamented with a pattern similar to that in Grammonota. Simon says he has specimens of several related species from Venezuela still undescribed.

*Erigone praepulchra* Keyserling. Spinn. Amer. Therid. 2:172, pl. 17, fig. 223. 1886. From Peru. This is a true Erigone.

*Erigone simillima* Keyserling. Spinn. Amer. Therid. 2:170, pl. 17, fig. 231. 1886. From Alaska. Keyserling says that this is the same as the species described by Emerton as *E. longipalpis* but distinct from the European species. If this is true it would be identical with the species which we described as *E. blaesa* but the figure of the palpus makes it very improbable.

*Erigone taibo* Chamberlin. Mus. Comp. Zool. Bul. 60:234, pl. 17, fig. 5. 1916. From Peru. Described from females only. It is not related to Erigone.

*Lophocarenum triste* Banks. Phil. Acad. Nat. Sci. Proc. 1892, p. 35, pl. 4, fig. 1. This is true Erigone but as it was described from females only we have not been able to identify it.

*Erigone ursurpabilis* Keyserling. Spinn. Amer. Therid. 2:193, pl. 18, fig. 252. 1886. From the Aleutian Islands. Described from females only. We have not been able to recognize it.

## Key to the Species of Erigone, Males

1 Ventral process of patella of palpus reduced to a short protuberance (figure 71) . . . . . . . . *tenuipalpis* Emerton
Ventral process of patella of palpus of normal form and size . . . . . . . . 2

2 Femur of palpus without ventral teeth, or with a single small tooth (figures 18 and 21) . . . . . . . . 3
Femur of palpus with several ventral teeth . . . . . . . . 6

3 A ventral process on both patella and tibia . . . . . . . . *barrowsi* n. sp.
A ventral process on patella only . . . . . . . . 4

4 Femur of palpus with a single ventral tooth, near base . . *autumnalis* Emerton
Femur of palpus without teeth below . . . . . . . . 5

5 Median tooth of embolic division of the fluted type . . . . . . *ourania* n. sp.
Median tooth of embolic division not of fluted type . . *brevidentata* Emerton

6 Median tooth of embolic division large, curving out over the scaphium with the tip dilated and strongly fluted on the mesal and posterior sides (figures 51 and 52) . . . . . . . . 7
Median tooth not of this form . . . . . . . . 18

7 Patella with distinct tooth near middle (western states) *dentosa* Cambridge
Patella without distinct tooth near middle . . . . . . . . 8

8 Patella with ventral apical process extremely long and incurved at tip *psychrophila* Thorell
Patella with ventral process not of this form . . . . . . . . 9

9 Femur of palpus with a sharp bend near base . . . . . . . . 10
Femur of palpus gradually curved upward near base, not sharply bent . . . 13

10 Tooth on ventral face of tibia acute . . . . . . . . 11
Tooth on ventral face of tibia blunt . . . . . . . . 12

11 Posterior tooth of embolic division widened distally . . . . . . . . *labra* n. sp.
Posterior tooth of embolic division with sides parallel . . . . . . . . *ostiaria* n. sp.

12 Edge of posterior tooth of embolic division smooth . . . . *whymperi* Cambridge
Edge of posterior tooth of embolic division notched . . . . . . . . *hypenema* n. sp.

13 Tibia of palpus gradually widened distally . . . . . . . . *metlakatla* n. sp.
Tibia of palpus more abruptly widened . . . . . . . . 14

14 Patella of palpus long and slender (figures 46 and 49) . . . . . . . . 15
Patella of palpus shorter (figures 1 and 62) . . . . . . . . 16

15 Posterior tooth of the embolic division abruptly widened distally (figures 76 and 77) .......... 17
Posterior tooth of the embolic division not abruptly widened (Atlantic Coast) .......... *ephala* n. sp.
16 Lateral angle of the posterior tooth of the embolic division with a distinct notch (Atlantic coast) .......... *aletris* n. sp.
Lateral angle of the posterior tooth of the embolic division entire, without a notch (northwestern states) .......... *olympias* n. sp.
17 Tooth on ventral face of tibia short and blunt .......... *zographica* n. sp.
Tooth on ventral face of tibia long and slightly recurved .. *paradisicola* n. sp.
18 Posterior tooth of embolic division lacking, scaphium triangular with two transverse ridges on posterior margin (figures 40 and 41) *dentigera* Cambridge
Posterior tooth of embolic division present .......... 19
19 Median tooth of embolic division crescent-shaped with two distinct points (figures 29 and 30) .......... *blaesa* n. sp.
Median tooth of embolic division formed from the upturned mesal edge of the scaphium .......... 20
20 Median tooth not strongly curved .......... *arctophylacis* n. sp.
Median tooth horseshoe-shaped .......... 21
21 Edges of horseshoe-shaped median tooth, low, rounded .......... 22
Edges of horseshoe-shaped median tooth raised into a high, thin, semicircular flange .......... 23
22 Median tooth pointed mesally .......... *atra* Blackwall
Median tooth rounded mesally (Alaska) .......... *sibirica* Kulczynski
23 Tibia of palpus gradually and moderately widened distally .... *alsaida* n. sp.
Tibia of palpus abruptly widened distally .......... *arctica* White

## DESCRIPTIONS OF SPECIES OF ERIGONE

### **Erigone aletris** n. sp.

*Male.* Length, 1.9 mm. Cephalothorax dull yellowish brown with darker radiating markings; viewed from above, gently rounded on the sides, nearly straight and converging opposite the eyes and evenly rounded across the front. The marginal row of teeth very irregular in size and spacing; usually one or two fair-sized teeth near posterior angle. Cephalothorax viewed from the side gently arched to the cervical groove where there is a broad shallow depression and then more strongly arched over the head to the anterior median eyes. Clypeus gently convex and projecting forward.

Posterior eyes in a straight line, equal, the median separated by two-thirds the diameter and from the lateral by the diameter. Anterior eyes in a slightly procurved line, the median not much smaller than the lateral, separated from the lateral by the radius and from each other by a little less.

Chelicerae brownish yellow, the lateral row of teeth short, consisting of small sharp teeth increasing in length from the base. The

other teeth on the face of chelicerae indicated by minute tubercles· Sternum and labium grayish, endites brownish yellow; face of endites armed with scattered small tubercles. Legs pale orange yellow; palpi darker. Abdomen gray.

Femur or palpus (figure 1) rather strongly curved upward near base, armed below with two rows of teeth, the outer row consisting of one basal tooth, four small blunt teeth at the curve, and the inner row of one basal tooth and four sharp widely spaced teeth. On the inner face of the femur there is a row of eight or nine small teeth, the first one placed far from the stridulating tooth. Tip of femur armed below with two small sharp teeth. Patella shorter than tibia with the ventral process relatively short. Ratio of length of femur to that of patella as 37 to 17; process of patella 6.

Tibia rather long, slender at base and moderately widened distally. The dorsal margin is excavated into a deep pit which is bounded mesally by a thin black curved ridge cut into two parts by a deep narrow notch. In front of the pit the margin of the tibia is thin, semitransparent, rounded in front and with a small acute point at the mesal angle. Ventral face of the tibia with a low protuberance instead of a tooth. Embolic division similar to that of *hypenema* but the posterior tooth is narrower and separated from the scaphium by a wider rounded notch (figures 2 and 3).

*Female*. Length, 1.9 mm. Similar to male in form and color. The marginal teeth on cephalothorax very small, almost lacking. Teeth on face of chelicerae replaced by minute tubercules. Epigynum with a shallow notch in the hind margin (figure 4).

Holotype male, allotype, female, Water Mill, N. Y.

New York: Water Mill, June 26, 1924, 3♂ 8♀. In shade of plants on beach; Sea Cliff, 1♂ (Banks).

Maine: Thomaston, Aug. 15, 1913, 2♂.

Massachusetts: Oak island, Lynn, April 30, 1911, 1♂; Plum Island, Sept. 12, 1911, 13♂ (Emerton); Ipswich, Aug. 1900, 4♂ (Emerton).

### **Erigone alsaida** n. sp.

*Male*. Length, 2.6 mm. Cephalothorax reddish orange yellow with darker radiating lines; viewed from above, rather broad, rounded on the sides with the sides nearly straight and converging toward the front, rounded across the front; viewed from the side, thorax rather low, gently arched to the cervical groove and then strongly elevated and arched over the back of the head to the posterior eyes. Head high. Margin of cephalothorax armed with a

row of rather strong teeth, smaller and farther apart posteriorly. Clypeus straight and slanting forward.

Posterior eyes in a straight line, equal, the median separated by a little less than the diameter and from the lateral by the diameter. Anterior eyes in a gently procurved line, the median smaller than the lateral, separated by a little more than the radius and from the lateral by a little more. Chelicerae robust, angulate externally, armed on the face laterally with a row of seven or eight small sharp teeth, inner margin with a group of eight or nine small sharp teeth or tubercles mostly arranged in two rows. Upper margin of the furrow armed with five teeth, the fourth the longest. Sternum and labium dark gray almost black. Hind coxae separated by less than the diameter. Endites reddish orange, armed with an irregular double row of tubercles across the face. Legs and palpi clear orange yellow. Abdomen gray.

Femur of palpus (figure 5) curved inward and upward at base and curved downward at tip. Tip with a single tooth below. Femur armed below with two rows of teeth; the outer row consists of a low blunt tooth near base, three strong teeth at the curve followed by two shorter teeth near by; inner row consists of five long teeth close together in the vicinity of the curve followed by two others more widely separated (not shown in drawing because broken off in specimen). Patella slender at base, gently curved downward near base and then nearly straight, gradually thickened toward apex, armed below with a long rather thick apophysis. Ratio of length of femur to that of patella as 44 to 22; ventral apophysis of patella 9. Tibia shorter than patella, moderately widened distally without a tooth on ventral face. The dorsal margin very deeply excavated to form a deep cavity which is covered from behind by a broad process the front margin of which is rounded with a small pointed hyaline projection on anterio-lateral angle. Viewed from the side the margin of tibia broadly excavated with a tooth just above base of paracymbium which is really the true dorsal margin where it joins the edge of the dorsal excavation. Embolic division (figure 6) has the anterior tooth ending in a curved process pointed in front and behind, the ejaculatory duct opens through the latter. The posterior tooth is tongue-shaped, narrow, strongly curved and lies far over on the lateral side of the bulb. The median tooth is a high semicircular ridge which lies on the mesal side of the scaphium; the edges are very finely serrate. Mesal tooth straight and rather thick.

Type: male.

Ohio: Sugar Grove, April 1913. 1♂ (Barrows).

### **Erigone arctica** White

*Micryphantes arcticus* White in Sutherland Jour. Voyage Baffin Bay and Barrow Straits 2:CCX, fig. 11, 12. 1852.

*Erigone arctica* Emerton. Rep't Can. Arctic Exped. 3: 3H, pl. 1, fig. 1. 1919.

*Male.* Length, 2.7 mm. Cephalothorax varying from light brown with darker radiating markings to dark chocolate brown; with a distinct submarginal furrow, the margin armed with distinct teeth, the teeth small or lacking on posterior two-thirds. Cephalothorax viewed from the side, rather flat posteriorly, gently arched to the cervical groove where there is a distinct but shallow depression then rounded over the back of the head to the posterior eyes. Head rather high. Clypeus straight, strongly projecting forward.

Posterior eyes in a straight line, equal and equidistant, separated by a little more than the diameter. Anterior eyes in a gently procurved line, the median only a little smaller than the lateral, separated by two-thirds the diameter and from the lateral by the diameter.

Sternum, labium and endites dark reddish, nearly black. Endites studded with rounded tubercles with a short, sharp tooth between end of serrula and trochanter. Chelicerae reddish brown, stout at base, strongly angulate externally, armed on the face toward the side with a row of five to six strong teeth and near the inner margin with four or five smaller teeth. Legs and palpi yellow orange.

Femur of palpus (figure 7) gently curved upward and inward at base and downward at tip. Only one ventral tooth at apex, the one on the outer side. Femur armed below with two rows of teeth, the outer row consists of a blunt rounded tooth near base, two short but sharper teeth at the curve followed by three or four minute setigerous tubercles placed at increasing distances from each other distally; the inner row consists of a minute tooth near base, a group of six teeth of about equal size and fairly evenly spaced in the region of the curve, followed by two similar teeth at some distance and one smaller tooth about half way from the last to the apex. Row of teeth on mesal side of femur consists of 10 to 12 minute tubercles, the first one much farther from the stridulating tooth than from the next in the row. Patella slender at base, thickened distally with the usual ventral process. Ratio of length of femur to that of patella as 35 to 16; process of patella 8. Tibia short, slender at base, compressed, greatly widened dorso-ventrally towards tip, dorsally armed with a large triangular blunt process beneath which there is a deep cavity between the base of the process and the true dorsal margin of the tibia. Viewed from the side the margin appears broadly and evenly excavated with a distinct tooth just back of the

paracymbium. This tooth is the end of the ridge-like dorsal margin. The tip of this tooth is nearer the tip of the dorsal process than to the tip of the ventral. On the ventral face of the tibia is a small distinct blunt tooth. Ventral notch deep, rounded, the side towards the paracymbium much longer than the opposite one. Embolic division (figures 8–10) resembles somewhat the *atra* type. The anterior tooth ends in a sharp point just back of which is the opening of the ejaculatory duct; this tooth is deeply grooved and the mesal edge turned up to form a ridge which extends backward around the edge of the scaphium to the posterior angle. The posterior tooth is tongue-shaped, rather long, thin and flat and gently curved; it arises not far from the base of the anterior tooth at right angles to it. The median tooth consists of a high thin ridge curved around in the form of a C, with the opening between the anterior and posterior teeth. This ridge flares outward and is higher on the side next to the posterior tooth. The mesal tooth is rather small.

Cockburn point, Northwest Territory, Canada, Sept. 1914, 2♂ 3♀, Can. Arctic Exped. (F. Johansen) Emerton det.; Bernard Harbor, Northwest Territory, Canada, Oct. 4, 1914, 1♂, Can. Arctic Exped. Emerton det.; Colville river delta, Alaska, June—July 1909, 1♂ 6♀ (R. M. Anderson), American Mus. Nat. Hist. no. 327. Emerton det.; Skagesbrand, Iceland, 1♂ 1♀ (Zool. Inst. Copenhagen); St Paul's island, Alaska, Aug. 6, 1916, 1♂. From stomach of *Arenaria interpres*. Biol. Surv. No. 145205. (Palpus only).

This species is closely related to *E. atra* but is larger and the armament of teeth is more strongly developed. The eyes seem to be relatively smaller. The dorsal margin of the tibia of the palpus is produced into a longer, narrower and more pointed lobe than in *E. atra*.

White's description and figures are not adequate to definitely determine what species he had but if the name is to be retained it should be applied to a species common in the general region in which his types were taken. His specimens were collected at Assistance bay. Some of our specimens were taken about 600 miles from the type locality. Apparently the commonest species in Arctic America is the one described above and we would retain the name *arctica* for it.

Cambridge (Ann. Mag. Nat. Hist. (Ser. 4) 20:278, pl. 8, fig. 3. 1877) described a specimen from Spitzbergen which he identified with *E. arctica* White, stating that it is very nearly allied to *E. longipalpis* Sund. L. Koch (K. Sv. Vet. Acad. Handl. 16, No. 5:39. 1879) recorded *E. arctica* from many localities in Siberia and Novaya

Zemlya with the statement that he agreed with Cambridge in regard to its close relationship with *E. longipalpis*. On this point see Kulczynski (Ann. Mus. Zool. Acad. Imp. Sci. St Petersburg 7:342. 1902). Through the kindness of the authorities of the British Museum (Natural History) we have been permitted to examine one of Koch's specimens, a male, from Wajgatsch, Novaya Zemlya. We have compared it with specimens of *E. longipalpis* from France determined by E. Simon and believe it is merely a variety of that species. It is entirely distinct from the species which we identify as *arctica*. Kulczynski (Acad. Sci. Cracovie Bul. Intern. 1902, p. 543) figured and described in detail a species which he considered as *arctica* but Simon (Ar. Fr. 6:444. 1926) after an examination of a male received from Kulczynski considers it the same as *capra*.

In the specimens from Iceland the embolic division is of the same form as in the specimens from boreal America but the dorsal process of the tibia is broader, not so pointed when viewed from above and the lateral tooth on the margin is relatively much nearer to the tip of the dorsal process.

### **Erigone arctophylacis** n. sp.

*Male.* Length, 2.2 mm. Cephalothorax brownish with darker radiating lines; viewed from above, rather broad, the sides convergent in straight lines toward the front, broadly rounded across the front. The marginal teeth of moderate size but very irregular, extending nearly to the posterior angles. Cephalothorax viewed from the side, rather low and gently arched on the thorax with a distinct broad depression at the cervical groove; head only moderately high, gently arched over the back. Clypeus straight, slanting strongly forward.

Posterior eyes in a straight line, the median separated by the diameter and only very slightly farther from the lateral. Anterior eyes in a slightly procurved line, the median only a little smaller than the lateral, separated by half the radius and from the lateral by a little less than the diameter. Sternum, labium and endites dark brown. Lateral row of teeth on face of chelicera confined to basal half and consisting of six teeth of moderate size. On the inner margin there are two irregular rows of small teeth.

Femur of palpus (figure 13) moderately stout, curved upward near base but not abruptly bent, curved downward at tip, armed below at tip with a very small tooth on the outer side only. Femur armed below with two rows of teeth; the outer row consists of one small tooth near the base and three longer teeth at the curve; the inner

row consists of a small tooth near the base, a long tooth at the bend and two or three smaller teeth towards the tip. Femur armed on the inner side with a row of minute teeth rather close together, the distance from the stridulating tooth to the first tooth of the row not twice the interval between the first and second. Ratio of length of femur to that of patella as 38 to 17; process of patella, 9. Patella slender for basal two-thirds and then bent upward and somewhat thickened; ventral process rather thick. Tibia about as long as patella, compressed and greatly widened dorso-laterally with a distinct tooth on ventral face. The dorsal margin has a deep excavation covered by a broad process back of the true margin. This dorsal process or lobe is broad and obliquely truncate laterally; it is much shorter than in *E. arctica*. The embolic division (figures 11 and 12) has the anterior tooth of the usual form, with a sharp point on the lateral side, deeply grooved and with a distinct ridge on the mesal side of the groove. Posteriorly this mesal ridge suddenly becomes widened into a broad blackish flange which extends along the mesal side of the scaphium to the base of the posterior tooth. This flange has the edge minutely serrate. It may be considered as the median tooth. The posterior tooth arises behind and below the median tooth and curves ventrally and mesally lying obliquely across the palpal organ with the tip on the mesal side. It is rather short and thick and is bluntly rounded at tip. Compared with Kulczynski's figures it looks more like *capra* than *arctica*.

Type, male. Moore bay, Bathurst Inlet, Northwest Territory, Canada, Aug. 19, 1915. O'Neil coll. Determined by Emerton as *E. arctica* White.

## **Erigone atra** Blackwall

*Linyphia longipalpis* (var. β) Sundevall. Svenska Spindl. p. 25. 1830

*Erigone atra* Blackwall. London & Edinburgh Phil. Mag. (Ser. 3) 3:195. 1833.

*Erigone vagabunda* Westring. Araneae Svecicae, p. 597. 1861

*Neriene longipalpis* Blackwall. Spid. Gt Brit. 2:274, pl. 22, fig. 188. 1864

*Erigone dentipalpa* Ohlert. Aran. Prov. Preussen p. 50. 1867

*Erigone dentipalpis* Menge. Preussische Spinnen, p. 198, pl. 38, tab. 94. 1868

*Erigone longipalpis* L. Koch. Zeits. Ferdinandeum 14:200. 1869

*Neriene atra* Cambridge. Linn. Soc. Lond. Trans. 28:448, pl. 34, fig. 22. 1873

*Erigone arctica* Cambridge. Ann. Mag. Nat. Hist. (Ser. 4) 20:278, pl. 8, fig. 3. 1877

*Neriene atra* Cambridge. Spiders Dorset p. 106. 1879

*Erigone atra* L. Koch. Zeits. Ferdinandeum 17:282–83. 1872

*Erigone persimilis* Cambridge. Zool. Soc. Lond. Proc. p. 394, pl. 46, fig. 1, 1875

*Erigone atra* L. Koch. K. Svenska Vet. Handl. (n. f.) 16(5):40. 1879

*Erigone longipalpis* Emerton. Conn. Acad. Sci. Trans. 6:59, pl. 17, fig. 9, 10 (in part). 1882

*Erigone atra* Hasselt. Tijdschr. Ent. 27:251. 1884

*Erigone atra* Simon. Ar. Fr. 5:528, figs. 323–26. 1884

*Erigone lantosquensis* Simon. Ar. Fr. 5:520, fig. 310. 1884

*Erigone atra* Dahl. Naturw. Ver. Schleswig-Holstein Schriften 6:78. 1886

*Erigone atra* Chyzer and Kulczynski. Aran. Hung. 2:90, pl. 3, fig. 38. 1894

*Erigone atra* Strand. Trömsö. Mus. Aarsh. 1900

*Erigone atra* Bösenburg. Spinn. Deutschl. p. 174, pl. 15, fig. 237. 1902

*Erigone atra* Kulczynski. Acad. Sci. Cracovie Intern. Bul. 1902, p. 546–53, pl. 35, fig. 13, 14, 29, 37, 49

*Erigone atra lantosquensis* Kulczynski. Same. p. 539, fig. 15

*Erigone atra* de Lessert. Cat. Ar. Suisse, p. 204. 1910

*Erigone atra* Jackson. Irish Nat. 1910, pl. 3, fig. 4

*Erigone atra* Simon. Ar. Fr. 6:444–45. 1926

*Male.* Length 2.1 mm. Cephalothorax varying from light brown to nearly black; viewed from above, rounded on the sides, the sides becoming nearly straight and convergent in front of the middle, broadly rounded across the front from the end of the marginal row of spines on one side to the other; viewed from the side, thorax rather low, gently arched to the cervical groove, head rather high, evenly rounded behind to the posterior eyes and armed with a median row of stiff spines directed upward and forward. Clypeus nearly straight, projecting strongly forward. Margin of cephalothorax armed with a row of teeth uneven in size and irregularly spaced. Posterior eyes in a straight line, separated by a little less than the diameter. Anterior eyes in a gently procurved line, the median nearly as large as the lateral, separated by a little less than the radius and from the lateral by the radius.

Sternum varying from dark brown over reddish orange to nearly black (in the lighter forms the darker color being in indistinctly radiating lines) smooth and shining with the usual narrow clear margin, rather broad, produced behind into a narrow truncate point. Hind coxae separated by nearly the diameter. Labium like sternum in color, the thickened edge like the endites. Endites yellow orange armed on the face with a row of small teeth. Chelicerae reddish yellow orange, rather stout, angulate externally, armed on the face laterally with a row of six or seven small teeth decreasing in size, with a row of five along the inner margin, a diagonal row of very small teeth connecting these two rows and one tooth near the inner row but not in any row. First leg has the trochanter armed above with one tooth and with a row of small teeth in front of base of femora. Abdomen light gray.

Femur of palpus (figure 14) long and slender, strongly curved inward and upward at base and downward at tip, armed below with two rows of teeth; the outer row consists of a small tooth near the base, two longer teeth at the bend followed by three or four shorter teeth decreasing in size; the inner ventral row consists of six or eight small teeth; the row on the mesal face consists of about twelve small teeth decreasing in size, the first tooth being a long distance from the stridulating tooth. The ventral tooth at apex of femur small and triangular. Ratio of length of femur to that of patella as 45 to 20; ventral process of patella 9. Patella slender at base gradually widened distally.

Tibia slender at base, compressed and strongly widened distally, sometimes armed below on the face with a distinct tooth but more often unarmed or with a very small tooth, armed dorsally with a thin, broad, evenly rounded lobe, beneath which there is a deep cavity between the base of the lobe and the true apical margin of the tibia; viewed from the side, the margin appears broadly and evenly excavated with a broad, blunt, rounded tooth (the exterior process) just back of the paracymbium. The tip of this process is nearer the tip of the dorsal process than to the tip of the ventral process. This tooth marks the place where the true dorsal margin meets the edge of the cavity under the dorsal lobe. The embolic division (figures 15–17) much broader than long; the anterior tooth short, deeply grooved; the outer edge of the groove continues as a ridge mesally along the anterior edge of the central part of the scaphium forming a rounded anterior mesal angle and then continues along the mesal margin to the posterior angle where it forms a right angle with the posterior margin. The posterior margin nearly straight, armed with a ridge which is low mesally and gradually becomes higher ending in an oblique, transverse, rounded point. This tooth and the marginal ridge together form a horseshoe-shaped elevation which by Kulczynski is considered as forming the median tooth. The posterior tooth is a long, thin, strongly curved tongue-like process, light in color, which arises beneath the median tooth and stands erect just back of it lying on the exterior half of the genital bulb. Mesal tooth of the usual form.

Type locality: Denbighshire, England.

New York: Summit of Mount McIntyre, July 1, 1923, 1♂; Wilmington, Aug. 22, 1926, 2♂; Long Lake, July 1884, 1♂ (Emerton); Rochester, Dec. 3, 1927, 3♂ 5♀ (causing trouble in greenhouse by spinning webs on roses); Geneva, July, 1918, 1♂; Cayuta lake, July 11, 1920, 1♂; Taughannock falls, July, 1911, 1♂; Aug. 12, 1917, 1♂

(Dietrich); Ithaca, 2♂; Oct. 2♂ 2♀; July 1910, 1♂; July 16, 1920, 1♂; Aug. 15, 1920, 1♂; Mar. 1♂; June 1♂; Aug. 29, 1912, 2♂; Aug. 1916 2♂ 1♀; Aug. 3, 1909, 1♂ (Bryant); Waterville, Aug. 13, 1916, 1♂; Tackawasick pond, June 25, 1920, 1♂; New York City, Battery and Washington square, Oct. 29, 1904, 10♂; Lloyds Neck, July 31, 1907, 1♂ (Bryant); Slaterville, July 12, 1927, 1♂ [floating on the surface of a brook (P. Needham)].

Nova Scotia: Weymouth, July 1924, 1♂ 5♀ (Bryant).

Maine: Sebasticook lake, Aug. 24, 1925, 3♂ 1♀.

New Hampshire: Intervale, Aug. 14, 1914, 1♂; Hollis, 1♂; Aug. 1888, 2♂; Lyndeboro, June 5, 1923, 1♂ (Bryant); Mount Washington, 1♂ (Banks).

Massachusetts: Cambridge, Nov. 17, 1922, 22♂ 27♀. On fence.; Framingham, Nov. 1916, 1♂ (Frost); Wellfleet, June 25, 1♂ (Emerton); Shirley, June 18, 1917, 1♂ (Bryant); Readville, Nov. 1, 1922, 10♂ (Emerton); Boston, Oct. 1877, 13♂ (Emerton); Duxbury, June 4, 1921, 1♂ (Bryant); Allston, June 4, 1904, 2♂ (Bryant).

Pennsylvania: Arendtsville, Aug. 12, 1924, 2♂ (S. W. Frost), from stomach of *Rana pipiens*.

Ohio: Gambier, June 20, 1905, 1♂ (Nelson).

Ontario: Sanford, June 1906, 1♂ 2♀.

Saskatchewan: Saskatoon 1♂.

That the species described by Cambridge as *E. persimilis*, is the same as *E. atra* Blackwall of Europe is based on a careful comparison of American specimens with examples from France determined by Simon. We have also compared specimens from England, and from the Don region of Russia. Cambridge states that it is very closely allied to *atra*, from which he distinguishes it by the presence of a median row of setigerous tubercles on the head, the form of the dorsal margin of the tibia of the male palpus and the presence of a small tooth on the ventral face of the tibia. The row of minute tubercles is present in specimens of *atra* from France, the form of the dorsal margin of the tibia is the same when viewed from the same angle and in some American specimens there is a distinct tooth on the ventral face of the tibia while in others it is entirely lacking. Cambridge had only one American specimen for examination. The teeth on the femur of the palpus are similar in form and arrangement making due allowance for individual variation, which is considerable in the series before us.

## Erigone autumnalis Emerton

*Erigone autumnalis* Emerton. Conn. Acad. Sci. Trans. 6:58, pl. 17, fig. 8. 1882
*Erigone autumnalis* Keyserling. Spin. Amer. Therid. 2:171, pl. 17, fig. 232. 1886
*Erigone autumnalis* Emerton. Common Spiders, p. 151, figs. 366, 367. 1902
*Erigone autumnalis* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 314

*Male.* Length, 1.5 mm. Cephalothorax reddish orange slightly suffused with gray; viewed from above, with the sides evenly rounded the whole length, not convergent in front, broadly rounded across the front; viewed from the side, ascending gradually from the posterior margin to the eyes, only slightly arched over the back of head. Marginal row of teeth lacking except on posterior angle where there are two or three very small ones. Clypeus straight, slanting forward.

Posterior eyes in a straight line, equal and equidistant, separated by a little less than the diameter. Anterior eyes in a slightly procurved line, the median smaller than the lateral, separated by the radius and a little farther from the lateral.

Chelicerae reddish orange, stout at base, divaricate, with the claw long and somewhat sinuate, armed on face at base with two small sharp teeth. Sternum and labium gray over orange yellow, darker towards edge. Endites thickened, orange yellow armed with a tubercle at the end of the serrula and a long sharp tooth half way to the base of palpus; face with a few small tubercles. Legs and palpi pale yellowish orange. Abdomen gray.

Trochanter of palpus with a large projection below. Femur nearly cylindrical slightly curved inward, armed below with a single row of tubercles the basal one much larger than the others, inner face armed with a row of minute tubercles (figure 18). Patella slender at base curved downward and thickened distally; ventral apophysis long, slender and somewhat recurved. Ratio of length of femur to that of patella as 16 to 8; ventral apophysis of patella 5. Tibia obconic, the dorsal margin produced into a short pointed process, laterally from this the surface is shallowly depressed. Viewed from the side the margin broadly excavated with a small tooth just above base of paracymbium. Paracymbium broadly notched on both sides. Embolic division (figures 19 and 20) has the mesal tooth short. Anterior tooth short, rounded at apex with the sharp point a little back from the tip, the outside of the groove high and continued on mesal side of scaphium as a sharp ridge. Median tooth very large, triangular, pointed and directed forward, the ventral edge finely serrate. Posterior tooth flat. broad at base, gradually narrowed toward

apex, tip rounded with a slender fingerlike process on the anterior angle.

*Female.* Length, 1.5 mm. Cephalothorax grayish over reddish orange, blackish along margin, narrower than in male especially in front, head not so wide or high. Chelicerae normal without lateral teeth. Endites smaller than in male without sharp tooth in front.

Epigynum a transversely wrinkled plate with the posterior margin nearly straight, slightly curved forward at the ends and with a minute notch in the middle for the extremely small median tubercle.

Type localities: Boston, Mass. and New Haven, Conn.

New York: Barneveld, Aug. 21, 1919, 1 ♂ ; Ithaca, July 13, 1919, 1 ♂ , Aug. 1916, 2 ♂, no date, 1 ♂ ; McLean, May 30, 1919, 1 ♂; Oyster Bay, 2 ♂ (Chamberlin); Cold Spring Harbor, July 6, 1907, 2 ♂ , Aug. 1917, 3 ♂ (Bryant).

Maine: Islesboro, Aug. 15, 1913, 1 ♂ (Emerton).

New Hampshire: Hollis, Aug. 1888, 9 ♂ (Fox); Intervale, July 1913, 1 ♂ (Bryant); Chocorua, June 1, 1902, 1 ♂ (Bryant).

Massachusetts: Readville, Oct. 1916, 1 ♂ (Emerton); Duxbury, June 24, 1921, 1 ♂ (Bryant).

New Jersey: Jamesburg, 4 ♂ (Banks).

Maryland: Hagerstown, March 1915, 1 ♂ (Pennington).

District of Columbia: Aug. 2 ♂ , May, 3 ♂ (Fox); Washington, several specimens without date (Banks) (Chamberlin).

Virginia: Alexandria, June, 1 ♂ (Fox); Covington, Sept. 1905, 1 ♂ ; East Falls Church, June 30, 1926, 1 ♂ .

North Carolina: Black mountain, May, 1 ♂ (Banks).

Tennessee: Glenraven, July 1905, 1 ♂ (Chamberlin).

Florida: Canal Point, Jan. 1921, 1 ♂ (Leonard); Gainesville, Feb. 6, 1925, 1 ♂ (Barrows), Jan. 1, 1926, 1 ♂ (Hubbell), May 16, 1926, 1 ♂ (Hubbell); Fishers island, St Augustine, March 27, 1926, (Hubbell); Rock Bluff, April 4, 1927, 2 ♂; Dead lake, Wewahitchka, April 6, 1927, 1 ♂ ; Newnans lake, May 15, 1926, 1 ♂ (Hubbell).

Kentucky: Brooklyn Bridge, Jessamine county, June 28, 1925, 1 ♂ .

Illinois: Salts, July 3, 1926, 1 ♀ (Smith).

Mississippi: Oxford, 1905, 9 ♂ (Fulton); Bay St Louis, April 23, 1892, 1 ♂ (Bailey) from stomach of *Bufo quercicus*.

Missouri: Columbia, July 1905, 1 ♂ , May, 1 ♂ ; Mountain Grove, Aug. 1905, 2 ♂ 1 ♀ ; Seligman, Oct. 1905, 1 ♂ .

Kansas: Wathena, Aug. 1905, 1 ♂ .

Oklahoma: No locality, Dec. 3, 1907, 1 ♂ (Hayhurst).

Texas: No locality, 1 ♂ ; Brazos county, 9 ♂ 1 ♀ .

## **Erigone barrowsi** n. sp.

*Male.* Length, 1.2 mm. Cephalothorax pale yellowish tinged with orange in front; viewed from above, rather broad, evenly rounded on the sides, only slightly narrowed toward front, broadly rounded across front; viewed from the side, gradually ascending behind then gently arched to the cervical groove where there is a slight depression and then arched over back of head to the eyes. Clypeus straight, slanting forward.

Posterior eyes in a straight line, equidistant, separated by a little less than the diameter. Anterior eyes in a straight line, the median smaller than the lateral, very close together on a black spot and separated from the lateral by the radius. Chelicerae stout, angulate externally, strongly divaricate with the claw long, and somewhat sinuate, armed with a lateral row of five or six small sharp teeth largest at the middle of the row. Upper margin of the furrow armed with two or three minute teeth, lower margin with one large and two small teeth. Sternum light gray over pale orange yellow, broad, rounded, the anterior margin not transverse but slanting forward. Labium small. Endites pale orange yellow, very large, smooth, with only a few scattered hairs; no sharp tooth in front as in *autumnalis*. Legs and palpi very pale straw yellow. Abdomen pale, grayish.

Femur of palpus (figure 21) cylindrical, gently curved downward, unarmed except for one or two minute tubercles on the inner face. Patella rather stout gently curved downward, the ventral apophysis rather short curved forward and inward at tip. Ratio of length of femur to that of patella as 19 to 9; ventral apophysis of patella 3. Tibia rather thick at base, moderately widened toward apex, ventrally produced at tip into an apophysis longer than that on patella; dorsally the margin is thin and produced into a broad round-pointed lobe. Paracymbium narrow, strongly curved. Embolic division (figures 22 and 23) has the anterior tooth short and broad but sharp-pointed; the mesal margin is raised into a high ridge and armed with a sharp tooth directed backward. The posterior tooth curves around mesally and ends in two points, the mesal one rounded and the lateral one acute (figure 25). The mesal edge of the scaphium thickened, rounded, considerably projecting and separated from posterior tooth by a deep rounded notch.

*Female.* Length, 1.4 mm. Similar to the male in color but paler. Cephalothorax with a narrow marginal dark gray line. Posterior median eyes separated by the diameter and from the lateral by the radius.

Epigynum a flat plate, rounded on the sides and behind with a small sharp notch in middle of hind margin (figure 24).

Holotype, male, allotype, female. Apalachicola, Fla.

Florida: Pensacola, Jan. 24, 1925, 3 ♂, 3 ♀. (W. M. Barrows); Apalachicola, Apr. 7, 1927, 1 ♂ 1 ♀.

### **Erigone blaesa** n. sp.

*Male.* Length, 2.6 mm. Cephalothorax reddish orange with the radiating lines darker, head lighter; viewed from above, rounded on the sides and then converging to the front without any constriction at the cervical groove, rounded across the front; viewed from the side, rather low and gently arched on the thoracic part; the head strongly elevated, rounded behind to the posterior median eyes. Clypeus straight, strongly projecting forward. The edge of the cephalothorax armed with a row of small teeth irregularly spaced and varying in size.

Posterior eyes in a very slightly recurved line, the median separated by the diameter and from the lateral by slightly more. Anterior eyes in a gently procurved line, the median as large as the lateral, separated from each other by half the radius and from the lateral by the radius.

Sternum smooth, shining, reddish orange strongly suffused with gray, darker at edge, a narrow band along edge clear red-orange, the tip produced between the hind coxae in a narrow rounded point. Hind coxae separated by the diameter. Labrium blackish. Endites reddish yellow orange armed with a double curved row of denticles across the under surface. There is also a black tooth below the outer end of the serrula and another one on the front margin near it. Chelicera reddish yellow orange armed on the face at base with a row of five or six small teeth, the basal one the largest, blunt; this row is continued to the tip by a series of setigerous tubercles; on the mesal side not far from the base there is also a group of four or five small teeth. Legs and palpi orange yellow. First leg with one small tooth above on trochanter and a row of four or five at base of femur above. Abdomen dark gray.

Femur of palpus (figure 26) long and slender, curved inward and upward at base and strongly bent downward at end, armed below with two rows of small teeth and on the inner side with one row; at the tip a rather long tooth projects downward and outward. The inner ventral row consists of four teeth, the basal farther apart than the others; the outer ventral row consists of two large teeth at the bend followed by five or six small denticles; the row on the mesal

surface consists of many small teeth decreasing in size, the first one a long distance from the stridulating tooth. Ratio of length of femur to that of patella as 40 to 17. Patella slender, gradually widened distally, armed at tip with a large ventrally directed process. Ratio of length of patella to that of process as 17 to 9. Tibia about as long as patella, moderately enlarged distally, provided dorsally with a round-pointed lobe more convex in outline laterally. Beneath this lobe there is a deep excavation between it and the true dorsal margin. When viewed from the side of the tibia (figure 27) the distal margin appears broadly rounded out with a black tooth nearer the dorsal side. This tooth marks the junction of the true dorsal margin and the edge of the excavation under the dorsal lobe. The ventral notch in the margin of the tibia is evenly rounded, as deep as wide and slightly constricted at the opening. There is no tooth on the ventral face of the tibia. Subtegulum wide and strongly chitinized, black on ventral face. Tegulum with the margin excavated for the reception of the posterior tooth of the embolic division. Median apophysis a thick brownish tonguelike process. Embolic division (figures 28–30) consists of a curved, boat-shaped scaphium, with a lateral quadrate plate extending over the edge of the tegulum and projecting toward the tip of the tarsus in a long sharp point, the mesal tooth. The posterior tooth thin, tonguelike and strongly curved upward; the median tooth double, ending in two points, the basal small and triangular, the other longer, tonguelike, rounded outwardly, straight on inner side, lying close to the anterior tooth; anterior tooth long, deeply grooved and ending in a pointed tip on the ventral face of which there is a small blunt tubercle at the base of which is the opening of the ejaculatory duct.

The epigynum consists of a broad rounded plate, concave and transversely wrinkled, with the posterior margin gently enlarged (figure 31). Holotype male. Shinnecock Hills, N. Y., June 15, 1919. Allotype female, same locality.

New York: Essex, Nov. 17, 1916 (Under log on lake shore); Ithaca, Apr. 6, 1922, 1 ♂ ; Apr. 1 ♂ ; Mar. 1 ♂ ; Mar. 24, 1920, 1 ♂ (on walk); Nov. 1 ♂; Sept. 1918, 1 ♂ ; Aug. 1916, 1 ♂ ; Aug. 1920, 1 ♂ ; Erie Basin, Brooklyn, Oct. 12, 1909, 1 ♂ (Krockour); Sheepshead Bay, June–July 1903, 1 ♂ 1 ♀ ; Cold Spring Harbor, June 1921, 1 ♂ (Anderson); Wading river (sound beach), June 16, 1919, 1 ♂ ; Quogue, June 15, 1919, 1 ♂ (on sand on beach); Shinnecock Hills, June 15, 1919, 10 ♂ 16 ♀ (on pebbles at the water's edge in a little inlet); Riverhead, May 22, 1928, 1 ♂ (Crosby).

Labrador: Assiwaban river, 30 miles inland, Sept. 1921, 3 ♂ , 1 ♀ (F. W. Waugh) in Emerton's collection.

Massachusetts: Winthrop beach, Nov. 12, 1922, 1 ♂ ; Woods Hole, July 10, 1919, 5 ♂ 2 ♀ (Forbes); Provincetown, Sept. 10, 1910, 3 ♂ 2 ♀ (Emerton); Wellfleet, June 25, 2 ♂ (Emerton); Martha's Vineyard, July 15, 1913, 2 ♂ (Emerton).

Rhode Island: Buttonwoods, June 20, 1912, several specimens (Emerton).

New Jersey: Palisades-on-Hudson, June 20, 1908, 1 ♂ .

Ohio: Columbus, June 23, 1922, 1 ♂ (Barrows).

Missouri: Columbia, July 1905, 6 ♂ , June, 18 ♂ .

Montana: Sand creek, Capitol, June 3, 1916, Biological Survey Nos. 1626 and 1666, 3 ♂ , from stomach of *Bufo woodhousii* (E. A. Preble and M. A. Hanna).

Colorado: Pike's Peak, above timber line, Aug. 1906, 1 ♂ (H. L. Shantz).

This species is found in collections most often under the name of *E. longipalpis* but a comparison with European specimens shows that it is entirely distinct. It does not seem to have received a name. Keyserling (Spinn. Amer. Therid. 2:170, 1884) described *E. simillima* from Alaska which he considered as probably identical with this form but his figure of the palpus would indicate that he had something else.

### **Erigone brevidentata** Emerton

*Erigone brevidentata* Emerton. Conn. Acad. Sci. Trans. 14:194, pl. 2, fig. 10. 1909

*Gonglydium atramontensis* Banks. Phila. Acad. Nat. Sci. Proc. 1911, p. 447, pl. 34, figs. 5, 8

*Tmeticus multidentatus* Emerton. Conn. Acad. Sci. Trans. 18:216, pl. 2, fig. 1. 1913

*Male.* Length, 1.2 mm. Cephalothorax yellowish suffused with grayish, darker along the edge and in radiating lines, lighter on the head; viewed from above, gently and evenly rounded to the cervical groove where there is a broad but distinct constriction, broadly rounded across the front; viewed from the side, gently arched behind and then gradually ascending to the posterior eyes. Clypeus convex, somewhat protruding.

Posterior eyes in a straight line, equal, separated by the diameter. Anterior eyes in a straight line, the median smaller than the lateral, very close to each other and separated from the lateral by the radius.

Chelicerae rather short and thick, armed laterally with a row of four teeth increasing in size, the lower one much larger than the others; near the inner margin are two small tubercles; on the face at the inner angle is a large downward directed tooth and on the

side just below the stridulating area is a distinct sharp dark tooth. Sternum and labium pale yellow irrorate with gray. Posterior coxae separated by less than the diameter. Endites rather thick, pale orange yellow lightly suffused with gray armed with a small tubercle near end of serrula and one or two in front of middle. Legs and palpi pale yellow. Abdomen dark gray. Epigastric plates very coarsely transversely striate.

Femur of palpus (figure 32) cylindrical, nearly straight, curved gently inward, armed below with a row of four very small tubercles widely spaced. Patella short curved downward and armed below with a very short pointed tooth. Tibia (figures 32 and 33) longer than patella, obconic, armed above near the tip with a high, thin, longitudinal ridge laterally from which there is a very deep nearly circular pit which is bounded in front by a curved ridge formed by the upturned apical margin of the segment, and continuous with the longitudinal ridge. Paracymbium broadly lunate with a distinct hook at tip. Embolic division (figures 34–36) has the mesal tooth rather broad at base and slender at tip. The anterior tooth small, slender and erect connected with a ridge which curves around the edge of the scaphium to the base of the posterior tooth. Median tooth long, black and sharp-pointed and directed toward tip of tarsus. Posterior tooth a broad, thin, tonguelike round-tipped process arising on the lateral side of the scaphium. Median apophysis appears as a broad rounded reddish process lying near the median tooth.

Type localities: Mount Holyoke, Mass., Fitzwilliam, N. H.

New York: Ithaca, July 12, 1925, 1♂.

North Carolina: Black Mountain, May, 1♂ (Banks) type of *G. atramontensis*.

This species has also been recorded by Emerton from Massachusetts: Monponsett; New Hampshire: Uncanoonuc Mountain; Vermont: Brandon.

### **Erigone dentigera** Cambridge

*Erigone dentigera* Cambridge. Zool. Soc. London Proc. 1874, p. 429

*Erigone dentigera* Cambridge. Zool. Soc. London Proc. 1875, p. 394, pl. 46, fig. 2

*Erigone dentigera* Emerton. Conn. Acad. Sci. Trans. 6:59, pl. 17, figs. 9, 10 in part. 1882

*Erigone dentigera* Emerton. Common Spiders, p. 149, fig. 361–65. 1902

*Erigone dentigera* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 314

*Erigone persimilis* Crosby. Same, p. 339. 1905

*Male.* Length, 2.1 mm. Cephalothorax reddish orange strongly suffused with gray especially on the radiating lines; viewed from

above, rounded on the sides without any constriction at the cervical groove, broadly rounded in front; viewed from the side, with the thoracic part low, gently arched, head moderately high, rounded over the back to the posterior median eyes. Clypeus nearly straight, projecting strongly forward. Margin of cephalothorax armed with a row of small teeth irregularly spaced.

Posterior eyes in a straight line, separated by a little less than the diameter. Anterior eyes in a gently procurved line, the median smaller than the lateral separated by two-thirds the diameter and from the lateral by the same distance. Sternum dark brownish gray over orange, smooth and shining, produced behind in a squarish point. Hind coxae separated by the diameter. Labium same color as sternum except thickened apex which is gray. Endites reddish orange suffused with gray, armed on the face with two rows of small teeth. Chelicerae angulate externally, armed on the face laterally with a row of six small teeth and mesally with two rows of four or five each. Legs and palpi orange yellow, coxae grayish below. Abdomen gray.

Femur of palpus (figure 38) slender, curved inward and upward at base and downward at tip, armed below with two rows of small teeth, the inner row consisting of four teeth, the outer row of two teeth at the bend followed by two small denticles, and armed on the mesal face with a row of small teeth, the first one being widely distant from the stridulating tooth. Patella slender at base, gradually widened distally. Ratio of length of patella to process as 18 to 7. Ratio of length of femur to that of patella as 45 to 19. Tibia strongly compressed, and expanded distally, keeled below and armed with a small distinct tooth. Ventral notch narrow, rounded. Dorsal margin produced into a bluntly triangular lobe, obliquely truncate laterally. Viewed from the side, the margin of the tibia is broadly excavated with a high but narrow tooth at the junction of the true dorsal margin and the edge of the dorsal excavation. Embolic division (figures 39–41) broadly triangular; the anterior tooth sharp-pointed and deeply grooved; the outer margin of this groove is continued as a ridge along the mesal edge of the scaphium. Just above it and parallel to it lies the anterior arm of the V-shaped black median tooth. The posterior arm is a higher, transverse, gently curved, black ridge shallowly grooved. Just back of and beneath the posterior arm of the median tooth and parallel to it lies a transverse light-colored ridge which may represent a vestige of the posterior tooth. Median apophysis broad, round-pointed, finely dentate at tip.

Type locality. Beverly, Mass.

New York: Chapel pond, Essex county, June 27, 1923, 1♂; Ithaca, 1♂ (recorded by Banks as *E. longipalpis*); Aug. 29, 1912, 1♂; Aug. 1♂; McLean, May 30, 1919, 1♂ 1♀ (in bog); Slaterville, June 27, 1927, 1♂ (P. Needham); Tackawasick pond, June 25, 1920, 1♂; Kingston, Mar. 12, 1919, 1♂ 1♀; Sea Cliff, 1♂ (Banks); Sheepshead Bay, June–July, 1903, 1♂.

Ontario: Brantford, July 16, 1918, several ♂ ♀ (Waugh).

Massachusetts: Cambridge, Nov. 17, 1922, 1♂ (on fence); Essex, June 19, 1♂ (Emerton); Danvers, Aug. 1878, 1♂ (Emerton).

Connecticut: New Haven, Oct. 13, 1902, 1♂ (Bryant).

New Jersey: Mays Landing, June 1925, 3♂ 2♀ (Fletcher).

Illinois: Evanston, June 13, 1925, 1♂ (Pickwell).

Florida: No locality, 1♂ (Biological Survey No. 1419). From stomach of *Bufo terrestris*. (E. A. Mearns).

Montana: Ekalaka, 4000 feet, May 29, 1916, 1♂ (Biological Survey no. 1648). From stomach of *Bufo woodhousii*. (M. A. Hanna)

Colorado: Pike's Peak, above timber line, Aug. 1906, 1♂ (H. L. Shantz).

## **Erigone dentosa** Cambridge

*Erigone dentosa* Cambridge. Biol. Centr. Amer. 1:128, pl. 16, fig. 1. 1894

*Erigone californica* Banks. Calif. Acad. Sci. Proc. (third ser.) 3:347, pl. 38, fig. 3. 1904

*Erigone plicita* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 339, pl. 29, fig. 7

*Male.* Length, 2 mm. Cephalothorax reddish orange, thorax with grayish radiating markings, head without so much gray. Cephalothorax viewed from above, with the sides gently curved, with a small but distinct constriction at the cervical groove, broadly rounded in front; viewed from the side, gently arched over the back to the cervical groove where there is a broad, shallow depression, head rather high, arched over the back to the posterior median eyes. Margin armed with a row of small teeth irregularly spaced and varying greatly in size. Clypeus nearly straight, projecting strongly forward.

Posterior eyes in a nearly straight line, very slightly procurved, the median separated by a little less than the diameter and from the lateral by a little more than the diameter. Anterior eyes in a gently procurved line, the median only a little smaller than the lateral, separated by half the radius and a little farther from the lateral.

Sternum dark reddish brown, nearly black at edge with the usual narrow clear margin. Labium nearly black at base. Endites light grayish orange yellow, the face armed with only a few minute tuber-

cles, a large sharp tooth near outer end of serrula. Chelicerae rather long, angulate externally, with the lateral row of teeth consisting of a blunt tooth at base, followed by two small teeth and then by two longer ones, sharp and curved downward; the row is continued by four or five minute teeth. (In many specimens the lateral row is more strongly developed and consists of six teeth gradually increasing in size.) Chelicera armed along the inner margin with a few small scattered teeth. Upper margin of the furrow armed with a blunt tooth at base of claw, with two long teeth at the inner angle, the distal one being the longer and somewhat curved; just beyond the base of the long tooth are two small triangular teeth. Legs and palpi orange yellow. Anterior femora armed at base on upper front side with a short row of small teeth. Abdomen gray.

Femur of palpus (figure 42) nearly straight for the basal third, and then bent sharply upward, curved downward at tip, armed ventrally with two rows of teeth; the outer row consists of one minute tooth near base, a large blunt, swollen tooth at the bend followed by a few minute setigerous tubercles; the inner row consists of a minute tooth near base, a sharp tooth just before bend and three long slender teeth at and just beyond the bend followed by two or three slender teeth on the distal half. Inner face of femur armed with a row of minute teeth, the first one distant from the stridulating tooth. Tip of femur armed below with two strong teeth. Trochanter armed above with two erect teeth. Patella slender at base, somewhat curved ventrally, thicker at apex, armed just beyond the middle with a strong tooth which is strongly bent mesally. Ratio of length of femur to that of patella as 29 to 16. Length of patella to length of distal ventral apophysis as 16 to 7. Tibia about as long as patella, slender at base, compressed and much widened distally, ventrally carinate and armed with a strong tooth, varying in size with different individuals. Near the dorsal margin there is a high quadrate longitudinal ridge cut toward the front by a deep narrow notch. Laterally from this ridge there is a deep rounded depression in front of which the margin is thin and produced into two short triangular teeth. Paracymbial notch broad, smoothly notched and without a tooth. Ventral notch as broad as deep, evenly rounded. The embolic division (figures 43–44) boat-shaped; the apical tooth deeply grooved and ending in a sharp point; the median tooth black, high, curved and twisted so that the tip lies transversely across the scaphium, the tip finely fluted on the posterior mesal side; posterior tooth transverse, broad, entire with the edge rounded, separated from the mesal side of the scaphium by only a shallow notch.

*Female.* Length, 2.2 mm. Similar to the male in form and color. Margin of cephalothorax without teeth, chelicerae with a lateral row of teeth smaller than in male. Epigynum transversely striate, with the posterior margin rolled up in a ridge with a smooth rounded tubercle in the middle (figure 45).

Type locality: Antigua, Guatemala.

California: Dalton creek, Fresno county, May 1920, 4800 ft. 5 ♂ 6 ♀ (Dietrich); Stanford University, 1920–21, 1 ♂; Stanford, 1 ♀ (P. B. Powell) type of *E. plicita* Crosby; Berkeley, Aug. 1919, 4 ♂ 2 ♀, Sept. 18, 1919, 1 ♂, Oct. 1919, 5 ♂ (Dietrich); Northfork, May 1920, 3 ♂ 9 ♀ (Dietrich); Lagoon, San Joaquin hills, Aug. 31, 1922, 1 ♀; San Francisco, July 15, 1904, 8 ♂ 20 ♀ (Blaisdel); Chiquito creek, Madera county, Aug. 20, 4100 feet 1 ♀ (Dietrich); Ukiah, Sept. 3, 2 ♂ 1 ♀; Lagoons in Laguna canon, Orange county, Aug. 24, 1922, 3 ♂, from stomach of *Hyla regilla* (Needham); Santa Rosa Id., 1 ♂ 2 ♀ (Banks); Sacramento 1 ♂ (Banks).

Washington: Pullman, 2 ♂ 2 ♀ (Banks); Longmire, Aug. 22, 1927, 2 ♂, 4 ♀.

Utah: Mill creek, 1 ♂ (Chamberlin); Chalk creek, 1 ♂ 2 ♀ (Chamberlin); Bear river near Amalga, June 30, 1926, 2 ♂, from exuvia of *Gomphus olivaceus* on clay bank (Needham).

This species varies considerably in the size of the teeth on the face of the chelicerae, in the size of the ventral tooth on tibia and of the median tooth of the patella. All gradations are to be found. The embolic division seems to be remarkably constant in form.

### **Erigone ephala** n. sp.

*Male.* Length, 2.3 mm. Very similar to *hypenema* in form and color but much smaller. The marginal row of teeth on the cephalothorax well developed, with one or two fairly large teeth near the posterior angle. The size and arrangement of the eyes is practically the same as in *hypenema*. Chelicerae armed with teeth very much as in that species.

Femur of palpus (figure 46) not so strongly curved nor so sharply angulate at the bend as in *hypenema;* armed below with two rows of teeth, the outer row consisting of a very small basal tooth, two larger ones at the bend (the proximal one smaller than the other and near the middle ventral line of the segment) followed by three minute teeth widely separated; the inner row consists of a blunt basal tooth opposite the stridulating tooth and five larger pointed teeth, one just before the bend and four not evenly spaced beyond it. Mesal face

of femur armed with a row of about a dozen small teeth, the basal one widely distant from the stridulating tooth. Femur armed ventrally at tip with two teeth. Ratio of length of femur to that of patella as 27 to 15; ventral process of patella 5. Patella nearly straight, slender at base, thickened distally; in the larger specimens there are often two or three small teeth on the inner lower side.

Tibia of the same type as in *hypenema*, with a notched longitudinal ridge above and a distinct tooth on ventral face. Embolic division (figures 47–48) of the same type as in *hypenema*. The posterior tooth broad with the end convex, finely and irregularly notched, the lateral angle slightly prolonged, acute. Median tooth more slender and curved over farther toward the mesal edge of the scaphium.

Type male. Falmouth, Me.

New York: Cold Spring Harbor, July 8, 1907, 1 ♂ (Bryant).

Maine: Falmouth, Aug. 30, 1925, 2 ♂; Lubec, July 30, 1913, several ♂ and ♀; Thomaston, Aug. 15, 1913, 2 ♂.

Massachusetts: Oak island, Lynn, April 30, 1911, 16 ♂ (Emerton); Plum island, Sept. 12, 1911, 14 ♂ (Emerton); Gloucester, Aug. 30, 1 ♂ (Emerton).

### **Erigone hypenema** n. sp.

*Male*. Length, 3 mm. Cephalothorax grayish brown over yellowish, darker along the radiating grooves with the head lighter; viewed from above, rather long, the sides gently curved, very slightly constricted at the cervical groove, broadly and evenly rounded in front, the margin armed with a row of rather long, slightly curved teeth irregularly spaced and of varying size; viewed from the side, the thorax moderately ascending and gently arched to the cervical groove where there is a slight depression; head high, strongly arched over the back. Clypeus slightly convex and projecting strongly forward.

Posterior eyes in a straight line, equal and equidistant, separated by the diameter. Anterior eyes in a nearly straight line, the median as large as the lateral, separated by the radius and a little farther from the lateral.

Sternum broadly triangular, dark brown over yellow orange with the usual clear marginal band. Hind coxae separated by less than the diameter. Endites reddish orange, suffused with gray armed on the face with nine or ten small tubercles, between the serrula and trochanter there is one small triangular denticle. Labium nearly black. Legs and palpi orange yellow, lightly suffused with gray. Chelicerae rather long, angulate externally, armed on the face with a

lateral row of six or seven teeth which curve downward, the row continued distally with four or five minute tubercles; along the inner margin there are two rows of small teeth of three or four each. Upper margin of the furrow armed at the angle with two long teeth, the one nearest the base of claw much the larger and sinuate, between this and the base are four or five minute teeth. Abdomen light gray.

Femur of palpus (figure 49) with the basal third nearly straight and thicker than the rest, then bent upward and curving downward at tip, angulate below at the bend; armed below with two rows of teeth, the outer row consisting of one small tooth near the base, a larger tooth midway to the bend, three larger teeth at the angle contiguous and forming together a common protuberance and bearing an extra tooth out of line on lateral side, the row continued beyond the bend by about four minute denticles widely separated; the inner row consisting of one tooth near the base separated from the others, five teeth near the angle and two others more widely spaced; armed on the inner face with a row of smaller teeth, extending from the angle to the tip, the first tooth widely distant from the stridulating tooth. Ratio of length of femur to that of patella as 60 to 40. Patella slender at base, strongly thickened distally. Ratio of length of patella to that of process as 40 to 19. Tibia three-fourths as long as patella, slender at base, compressed and expanded distally, armed on ventral face with small distinct tooth, the notch in ventral margin as deep as wide; near the dorso-lateral margin there is a high longitudinal ridge cut into two parts by a deep narrow notch; laterally from this ridge the surface of the tibia is deeply depressed forming a rounded cavity or pit. Paracymbial notch broad and rounded. The embolic division (figures 50–52) is of the *tirolensis* type. The anterior tooth deeply grooved and ending in a sharp point on the lateral side at the base of which is the opening of the ejaculatory duct. The ridge forming the mesal side of the groove continued along the side of the scaphium to the posterior angle. The median and posterior teeth arise on a common base on the lateral side of the scaphium. The median tooth curves out over the scaphium with the tip slightly dilated and strongly fluted on the mesal and posterior sides. This tooth is buttressed on the mesal side by a ridge running out on the face of the scaphium. The posterior tooth projects obliquely backward and inward; it is broad, quadrate, and notched at tip. The mesal projection is broad, rounded and armed with a short slender mesal tooth.

*Female.* Length, 3 mm. Similar to male in form and color. Teeth on margin of cephalothorax smaller than in male. Lateral

row of teeth on chelicera a little smaller than in male. Teeth on the upper margin of the furrow more uniform in size. Epigynum transversely wrinkled, lighter than the surrounding area; posterior margin sinuate, depressed in front of the median tubercle (figure 59).

Holotype male. Allotype female. Pike's Peak, Col.

Colorado: Summit of Pike's Peak, Aug. 27, 1924 (14109 feet) 20 ♂ 33 ♀, collected under stones with their small white eggsacs; Pike's Peak above timber line, Aug. 1906, 9 ♂ 8 ♀ ; (H. L. Shantz) Long's Peak, 14255 ft., Aug. 17, 1926, 4 ♂ 9 ♀ under granite flakes (H. H. Cleaves).

**Erigone labra** n. sp.

*Male.* Length, 3.2 mm. In general similar to *hypenema* but lighter in color and the teeth on the margin of cephalothorax are smaller, more uniform in size and more regularly spaced. The teeth of the lateral row on the chelicera are distinctly longer.

Femur of palpus (figure 53) rather sharply bent but not so strongly as in *hypenema*, armed below with two rows of teeth; the outer row consisting of a blunt tooth near the base, a stout tooth just before the bend, two teeth on a common protuberance at the bend followed by a broken row of small tubercles that does not reach the tip of segment; the inner row consists of rather long slender teeth, one near base, one just before the bend, two well separated at the bend and after a greater interval four teeth evenly spaced. Inner face of femur armed with a row of small teeth decreasing in size, the first one opposite the bend and distant from the stridulating tooth. Femur armed below at tip with two strong teeth. Patella long and slender at base armed on the inner ventral side with a row of three or four pointed teeth. The tibia is much like that of *hypenema* but the tooth on the ventral face is more acute. The palpal organ is practically the same (figures 54–55).

Type male.

British Columbia: Masset, 5 ♂ 1 ♀ .

**Erigone metlakatla** n. sp.

*Male.* Length, 2.5 mm. Cephalothorax dark brownish orange; viewed from above rather long, gently rounded on the sides, the sides nearly straight and converging toward the front, evenly rounded in front. The margin armed with a row of moderately strong teeth. Cephalothorax viewed from the side gradually ascending behind and then nearly level to the cervical groove where there is a shallow depression, then evenly arched over the head to the anterior median eyes. Clypeus straight and somewhat protruding.

Posterior eyes in a straight line, the median separated by the diameter and a little farther from the lateral. Anterior eyes in a very slightly procurved line, the median nearly as large as the lateral, separated by the radius and from the lateral by a little less than the diameter.

Chelicerae reddish orange, rather stout, rounded, angulate externally. The lateral row of teeth on the face small at base, increasing in size distally, the inner row consisting of four or five small teeth near the margin with a few scattered small tubercles near them. Sternum and labium dark gray. Endites lighter, thickened, armed with several distinct rounded tubercles. Legs and palpi orange-yellow. Abdomen dark gray.

Femur of palpus (figure 56) curved upward near base but not bent sharply as in *hypenema*, armed below with two rows of teeth, the outer row consisting of a short rounded tooth near the base, two large pointed teeth at the curve followed by four short rounded teeth extending toward tip, the inner row consisting of a small tooth near the base, three larger teeth at the curve and two sharp teeth well separated at the middle between the curve and the tip. On the inner face of femur there is a row of about fifteen small teeth, the basal one well separated from the stridulating tooth. Femur armed below at tip with two strong sharp teeth. Patella long, slender and curved at base, armed on the inner side with one or two small teeth near the middle; ventral process long and pointed. Ratio of length of femur to that of patella as 35 to 21, ventral process of patella 8. Tibia shorter than patella, slender at base, moderately widened distally, the ventral face with a low tooth. The longitudinal ridge and the deep pit at tip of tibia above about the same as in *hypenema*. Embolic division much as in *hypenema* but the posterior tooth is broader and finely dentate at the margin (figures 57–58).

Type male.

British Columbia: Metlakatla 1912, 1 ♂ (J. H. Keen).

**Erigone olympias** n. sp.

*Male*. Length, 1.8 mm. Cephalothorax dark reddish brown; viewed from above, similar in outline to *hypenema* but the marginal teeth are smaller or lacking posteriorly. The arrangement of the eyes is practically the same.

Chelicerae rather thick basally and strongly angulate laterally with the lateral row of teeth on the face small.

The femur of palpus (figure 62) does not have the sharp bend near the base but curves gradually and evenly upward and at the tip it

does not curve downward so strongly as in *hypenema*. It is armed below with two rows of teeth. The outer row consists of a small tooth near the base, a larger tooth at the curve with a smaller tooth on each side of it and one or two nearer the tip. The inner ventral row consists of four or five large teeth evenly and widely spaced. Inner face or femur armed with a row of seven or eight small teeth, the basal one distant from the stridulating tooth. There are two ventral teeth at apex of femur. Ratio of length of femur to that of patella as 39 to 17; process of patella 6. Patella rather strongly bent downward near base. Tibia of the same general form as in *hypenema*, with a longitudinal ridge above near the margin cut by a narrow notch and bounded laterally by a deep rounded excavation or pit; on the ventral face there is a low but distinct tooth. The embolic division of the genital bulb similar to *aletris* but the posterior tooth has the angle unnotched (figures 60 and 61).

Type: male, Friday Harbor, Wash., June 26, 1926 (Worley)

Washington: Olympia, 11 specimens (Kincaid); Seattle, Aug. 7, 1927, 1 ♂.

### **Erigone ostiaria** n. sp.

*Male*. Length, 2.1 mm. Cephalothorax dark brown with darker radiating markings; viewed from above, evenly rounded on the sides to the cervical groove then somewhat narrowed forward, rounded across the front. Marginal row of teeth of irregular size and unevenly spaced, largest opposite third coxa and very small behind this (figure 149). Cephalothorax viewed from the side, gently arched to the cervical groove where there is a distinct depression, then strongly arched over the head to the anterior median eyes. Clypeus slightly concave and projecting forward.

Posterior eyes in a straight line, equal, the median separated by a little less than the diameter and a little farther from the lateral. Anterior eyes in a straight line, median slightly smaller than the lateral, separated by a little more than the radius and from the lateral by the diameter.

Chelicerae lighter than the thorax, marginal row of teeth confined to the basal half, consisting of three or four teeth increasing in size distally; other teeth on face reduced to small tubercles. Sternum and labium dark brown; endites a little lighter. Face of endites armed with small tubercles. Legs and palpi orange yellow. Abdomen gray.

Femur of palpus rather broad, narrowest at base, broadest at the bend and then gradually tapering to the tip (figure 150). It is of the bent type although the angle at the bend is more obtuse than in

*hypenema.* The tip is distinctly curved downward and is armed with two ventral teeth, the outer one the larger. Femur armed ventrally with two rows of teeth, the outer row consisting of a low rounded tooth near the base, two large triangular, contiguous teeth at the bend followed by two smaller teeth of similar form more widely spaced toward the tip. The inner row consists of one sharp tooth before the bend, two teeth closer together at the bend and two teeth at a greater distance toward the tip. Inner face of femur armed with a row of small teeth, the first near the stridulating tooth followed by two teeth fairly close together at the middle of the segment, followed at a considerable interval by four small teeth near the tip. Ratio of length of femur to that of patella as 35 to 19; the ventral process 6. Patella slender at base, gradually thickened distally, evenly curved downward. Ventral process rather stout. Tibia slender at base, gradually but distinctly widened distally, the ventral face armed with a large, distinct tooth. Dorso-laterally the margin is hollowed out into a deep cavity which is bounded dorsally by a thin overhanging, longitudinal ridge, deeply incised at the middle. Embolic division of the *hypenema* type. The anterior tooth with a sharp ridge along the mesal side which is continued to the posterior angle of the scaphium. The median tooth concave in front, strongly fluted and when viewed from below extends to the mesal edge of the scaphium. Posterior tooth rather narrow with the sides parallel and with the posterior margin obliquely rounded and finely denticulate, separated from the posterior angle of the scaphium by a deep rounded notch. Mesal tooth rather short, stout (figure 151).

*Female.* Length 2.2 mm. Similar to the male in form and color. Lateral teeth on margin of cephalothorax greatly reduced. Lateral teeth on chelicerae reduced to a row of minute setigerous tubercles. Epigynum pale, of the usual form with a slight notch behind.

Type male; allotype female.

Washington: Edmonds, Aug. 16, 1927, 1 ♂ 3 ♀.

**Erigone ourania** n. sp.

*Male.* Length, 1.7 mm. Cephalothorax brownish orange with darker radiating lines, lighter on the head; viewed from above, gently rounded on the sides with the sides nearly straight and moderately convergent toward the front; the front rounded on the sides and straight across the middle. Cephalothorax viewed from the side, strongly tilted up in front, steeply ascending behind and arched over the back to the cervical groove where there is a broad and distinct depression, then steeply ascending and rounded over the back of the

head to the eyes. Clypeus distinctly concave and strongly protruding below.

Posterior eyes in a straight line, equidistant, separated by a little more than the radius. Anterior eyes in a procurved line equidistant, separated by the radius of the median; the median smaller than the lateral.

Chelicerae short and stout, armed laterally with a row of about six strong sharp teeth curved downward, the middle teeth being the larger. The row extends over three-fourths the length of the segment. Only a few small teeth on the inner margin. Sternum very dark gray, nearly black, over orange yellow. Posterior coxae separated by the diameter. Labium same color as sternum, narrow. Endites grayish, much lighter than sternum, robust, armed with a double diagonal row of small tubercles. Legs and palpi pale orange yellow. Abdomen dark gray.

Femur of palpus (figure 63) cylindrical, gently curved inward, not bent, armed ventro-laterally with five minute teeth. Patella slender at base, curved downward and thickened distally; the ventral apophysis stout at base, acute at tip. Ratio of length of femur to that of patella as 29 to 12; tibial apophysis 6. Tibia as long as patella, greatly widened distally, ventrally keeled and armed with a distinct tooth; dorsally deeply excavated, the cavity covered dorsally by a large process which at tip has the edge produced into a thin vertical plate. Tibia viewed from the side broadly excavated with a tooth just above the paracymbium which is really the ridge at the union of the true dorsal margin and the edge of the dorsal excavation. In ventral view the embolic division is pear-shaped (figure 64). The anterior tooth has a sharp point and is deeply grooved. The median tooth extremely long and slender lying obliquely across the scaphium with the tip slender, curved and twisted and deeply notched and fluted; basally it is broader and curved mesally. Posterior tooth separated from the median tooth by a narrow fissure; it is really a more elevated part of the ridge bounding the mesal and posterior margin of the scaphium (figure 65).

Type male.

China: Yuan Ming Yuan, Peking Oct. 11, 1924, 1 ♂, (P. W. Claassen coll.).

**Erigone paradisicola** n. sp.

*Male.* Length, 3 mm. Cephalothorax reddish brown with darker radiating markings; viewed from above, evenly rounded on the sides to the cervical groove, slightly narrowed and broadly rounded across the front. Marginal row of teeth uniform in size and evenly spaced.

Cephalothorax viewed from the side gently arched to the cervical groove and then abruptly arched over the head to the anterior median eyes. Clypeus slightly convex and projecting forward.

Posterior eyes in a slightly procurved line, equal, separated from each other by less than the diameter and from the lateral by more than the diameter. Anterior eyes in a straight line, equal, separated by the radius and from the lateral by a little less than the diameter.

Chelicerae reddish orange, the lateral row of teeth extending half the length of the segment; the middle teeth the longest. Other teeth on face of chelicerae indicated by minute tubercles. Sternum and labium dark brown, endites orange yellow. Face of endites armed with distinct tubercles. Legs and palpi dusky orange yellow. Abdomen gray.

Femur of palpus (figure 148) long and slender, strongly but evenly curved upward and inward at base. Armed ventrally with two rows of teeth, the outer row consisting of a blunt tooth near base, one just before the curve, three close together at the curve followed by a series of six setigerous tubercles; inner row consisting of a small tooth a little in advance of the stridulating tooth followed by seven fairly evenly spaced large teeth, the last one about a third of the distance from the tip of the segment. Inner face of femur armed with a row of evenly spaced small teeth, the first and second much nearer each other than the distance from the first to the stridulating tooth. Patella nearly straight, only slightly bent at base, slender, gradually thickened distally, the ventral process stout; ratio of length of femur to that of patella as 22 to 14; ventral process 5. Tibia long, slender at base and abruptly widened distally; tooth on ventral face long and slightly recurved; on the dorso-lateral surface there is a very deep cavity bounded mesally by a thin longitudinal ridge slightly notched at the middle. Basally this ridge is produced into a distinct, thin, rounded, erect tooth. The embolic division of the *hypenema* type; the median tooth viewed from below rather slender and concave in front, the flutings distinct; the posterior tooth of the same form as in *zographica* but without the narrow fissure at the lateral angle (figure 147).

*Female.* Length 2.9 mm. Darker in color than the male. Teeth on margin of cephalothorax and on chelicerae much reduced in size.

Epigynum with a slight notch in the hind margin.

Holotype male, allotype female.

Type locality, Paradise Camp, Mount Rainier, Wash. 6500 feet near snow Aug. 17, 1927, 11 ♂ 33 ♀.

### **Erigone psychrophila** Thorell

*Erigone psychrophila* Thorell. Öfvers. K. Vet.-Akad. Förh. 1871, p. 689

*Erigone psychrophila* Cambridge. Ann. Mag. Nat. Hist. (Ser. 4) 20:278, pl. 8, fig. 4. 1877

*Erigone psychrophila* Thorell. Amer. Nat. 12:393. 1878

*Erigone psychrophila* L. Koch. K. Svenska Vetensk-Akad. Handl. 16 (5):47, pl. 2, fig. 3. 1879

*Erigone psychrophila* Simon. Soc. Zool. Fr. Bul. 12:459. 1887

*Erigone fisheri* Cambridge. Linn. Soc. London Zool. Jour. 26:615, pl. 45, fig. 8. 1898

*Erigone psychrophila* Cambridge. Same, p. 613, pl. 45, fig. 1–7, 1898

*Erigone psychrophila* Sorensen. Vidensk. Medd. Naturh. Foren. Kjobenhavn ser. 5, 10:200. 1898

*Erigone psychrophila* Kulczynski. Acad. Sci. Cracovie Bul. Intern. 1902, p. 539–61, pl. 35, fig. 11, 24, 39, 51, 63

*Erigone psychrophila* Kulczynski. Ann. Mus. Zool. Acad. Imp. Sc. St Petersbourg, 8:337, pl. 7, figs. 1–4. 1902

*Erigone psychrophila* Strand. Rep't Second Norw. Exped. Arct. Fram. V. 1, no. 3, p. 28. 1905

*Erigone psychrophila* Strand. Fauna Arctica 4:447. 1906

*Erigone psychrophila* Kulczynski. Mem. Acad. Imp. Sic. St Petersbo urg, 17 (7):2. 1908.

*Erigone psychrophila* Emerton. Vidensk. Medd. Dansk Naturh. For. Kjobenhavn 70:143, fig. 1, 2. 1918

*Male.* Length, 3.3 mm. Cephalothorax very dark nearly black; viewed from above, rather short and broad, evenly rounded on the sides toward the front, the sides becoming nearly straight and strongly converging, rounded across the front; viewed from the side, rather low posteriorly, gently arched to the cervical groove, then rather steeply ascending and arched to the eyes. Cephalothorax strongly tilted upward in front. Clypeus gently convex, strongly protruding.

Posterior eyes in a straight line, the median separated by the diameter and distinctly farther from the lateral. Anterior eyes in a very slightly procurved line, the median as large as the lateral, separated by less than the radius and from the lateral by the diameter.

Chelicerae large, swollen basally, upper margin of furrow armed with five strong teeth; the teeth of the lateral row rather stout but not unusually long; inner margin with a group of small stout teeth. Sternum dark brown, nearly black. Posterior coxae separated by less than the diameter. Labium nearly black at base, broadly grayish yellow at apex. Endites grayish orange yellow, robust, armed anteriorly with a large triangular area of stout black tubercles and one slender sharp tooth. Legs long and slender, grayish over yellowish. Anterior femora armed below with a row of five or six sharp teeth.

Femur of palpus (figure 66) not sharply bent near base but gradually curved upward, strongly curved downward near tip, armed below with two rows of teeth; the outer row consists of two long, slender teeth at the curve, a shorter tooth nearer the base, a slender tooth just beyond the curve and four or five small tubercles toward the tip: the inner row consists of four long slender teeth at the curve with a small tooth near base and two or three large teeth towards the tip. Tip armed with two small rounded ventral teeth. Inner face of femur armed with a row of small sharp teeth, two of them over a third of the length from the base, then a space followed by four or five teeth decreasing in size toward the tip. Patella long and slender and provided with a very long slender ventral apophysis acute at tip and strongly curved inward. Ratio of length of femur to that of patella as 52 to 30; apophysis of patella 18. Tibia much shorter than patella without a tooth on ventral face; the dorsal margin with a deep rounded pit bounded mesally by a thin overhanging ridge deeply and narrowly notched in the middle.

The apical tooth of the embolic division (figures 67, 68 and 70) ends in a sharp point and is deeply grooved with the outer wall of the groove continued as a ridge along the mesal edge of the scaphium to the base of the posterior tooth. The median tooth is rather prominent, flattened and twisted so that it lies obliquely across the scaphium, the ventral edge at tip finely notched. The posterior tooth is connected anteriorly with the median tooth by a high ridge; it is rather small, triangular and is distant from the meso-posterior angle of the scaphium.

Type locality: Treurenberg bay, Spitzbergen.

Alaska: Head of Tsirku river, July or Aug. 1910, 1 ♂ (O. M. Leland coll.); Colville river, 1909, 2 ♂. (R. M. Anderson, coll.).

## **Erigone sibirica** Kulczynski

*Erigone sibirica* Kulczynski. Mem. Acad. Imp. Sci. St Petersbourg 18(7): 18, pl. 1, fig. 9. 1908

*Male.* Length, 3.5 mm. Cephalothorax dark reddish brown; viewed from above, the sides evenly rounded nearly to the cervical groove, broadly and evenly rounded across the front. The margin of cephalothorax armed with a row of rather large, sharp teeth, smaller opposite the third coxae. Cephalothorax viewed from the side, low and flat to the cervical groove and then rounded over the moderately high head to the posterior eyes. Clypeus gently convex, slanting strongly forward.

Posterior eyes in a straight line, the median separated by the diameter and a little farther from the lateral. Anterior eyes in a straight line, the median smaller than the lateral, separated by a little less than the diameter and from the lateral by a little more. Chelicerae bluntly angulate externally at the basal third, armed laterally on the face with a row of six teeth increasing in length. Group of teeth near inner margin rather stout. Sternum dark brown, broadly blackish along margin. Endites much lighter, the face coarsely tuberculate. Legs and palpi yellow orange. Abdomen gray.

Femur of palpus (figure 37) strongly curved upward at base and downward at tip, thickened at the curve but not bent as in *hypenema*, armed at tip below on the outer side with a rather long, acute, slightly curved tooth and on the inner side with a short, blunt tooth; armed below with two rows of teeth, the outer row consisting of three small blunt teeth before the turn, two large blunt teeth at the turn followed by a small blunt tooth out of line, a long sharp tooth, and then by three or four small teeth decreasing in size. The inner row consists of three teeth before the turn, two large teeth side by side at the turn, followed by seven long sharp teeth extending to the beginning of the distal curve. Inner face of femur with a row of small teeth (beyond the middle the row is double), the first tooth opposite the turn and separated from the second by a somewhat greater interval than that between the second and third. Patella long and slender, nearly straight, with the ventral process rather stout and long. Ratio of length of femur to that of patella as 52 to 32; ventral process 16. Tibia slender at base and rather abruptly widened distally, the ventral face armed with a distinct but low, blunt tooth. Dorsally the tibia is deeply hollowed out all the way across below the dorsal process. The latter when viewed from above is sharp-pointed. Tibia viewed from the outer side appears to be armed with a tooth nearer the tip of the dorsal than to the tip of the ventral process. This is really the true front margin of tibia where it joins the lateral margin of the excavation. This lateral tooth is much more acute than in *atra*. The embolic division is similar to that of *atra*. The median tooth is of the horseshoe type with the ridge black and evenly rounded, not so pointed mesally as in *atra*. Below the median tooth and parallel with it there is a secondary ridge running along the mesal face of the scaphium. We have not been able to see this ridge in *atra*. Mesal tooth of the usual form. Posterior tooth narrow, tongue-like, erect and curved forward as in *atra*.

Alaska 1 ♂. In the Banks collection at the Museum of Comparative Zoology.

This species is closely related to *capra* Simon, but the lateral tooth on the margin of the tibia is placed nearer the tip of the dorsal process than in that species.

## **Erigone tenuipalpis** Emerton

*Tmeticus tenuipalpis* Emerton. Conn. Acad. Sci. Trans. 16:395, pl. 3, fig. 4. 1911

*Male.* Length, 2.7 mm. Cephalothorax orange yellow with darker radiating lines; viewed from above, rather elongate, evenly rounded on the sides with a shallow constriction at the cervical groove, broadly rounded across the front; viewed from the side, rather low, gently ascending behind, nearly flat in outline above with a slight broad depression back of the head. Clypeus depressed below the eyes, nearly straight and slanting a little forward.

Posterior eyes in a slightly recurved line, equidistant, separated by the diameter. Anterior eyes in a straight line, the median smaller than the lateral, separated by the radius and from the lateral by the diameter. Sternum and labium dark; endites orange suffused with gray, tip pale yellowish. Coxae below yellow orange, suffused with gray and black at margin. Hind coxae separated by less than the diameter. Chelicerae divergent, armed on the face with a row of six strong teeth curved downward and decreasing in size towards the base of the segment. The claw very long. Upper margin of the furrow armed with three long teeth; the lower margin with four teeth. Legs and palpi yellow orange. Abdomen above dark gray with a double row of five or six large pale spots; under side broadly paler in the middle than on the sides.

Trochanter of palpus (figure 71) armed below with a large conical protuberance. Femur rather long and slender, slightly wider at tip than basally, gently curved inward, armed below at base with four or five setigerous tubercles. Patella long, curved downward, distinctly thickened distally with a small blunt protuberance below, recalling the ventral process of Erigone. Tibia (figure 72) much longer than patella, nearly straight, slender at base and gradually moderately widened distally; viewed from above and from the side the margin appears to end in a triangular point, at the base of which there is a blunt tooth (figure 73). This tooth represents the dorsal apophysis overhanging the excavation in the more typical Erigones. The tarsus is small and the alveolus occupies only the basal two thirds. The ratio of the lengths of the segments of the palpus: femur, 34; patella, 15; tibia, 21; tarsus, 14.

The embolic division (figure 74) consists of a more or less quadrate scaphium with rounded corners. Anteriorly it is armed with a thin squarish, erect tooth[t]; laterally toward the posterior end there is a small erect tooth at the base of which the ejaculatory duct opens on a minute tubercle[f]. On the mesal face of the scaphium there is a low minute tooth a little back of the middle[m].

*Female.* Length, 3.5 mm. Very similar to the male in form and color. Chelicerae without the row of teeth on the face. Upper margin of the furrow armed with five teeth, lower margin also with five, of which the distal two are much smaller than the others and close together. Epigynum a broad plate, narrowed behind and with a small triangular notch in the middle of the hind margin.

Type locality: Ipswich, Mass.

Massachusetts: Plum island, Sept. 12, 1911, 2 ♂ 1 ♀; Chatham, Cape Cod, Sept. 1913; Nantucket, July 10, 1913. All collected by Emerton.

Rhode Island: Newport, July 16, 1912 (Emerton).

Although this species is undoubtedly closely related to those species comprising the genus Erigone and must perforce be placed with them, it is a decidedly aberrant form. The teeth are strongly developed on the face of the chelicera, it is true, but they are only represented by minute setigerous tubercles on the femur of the palpus and are entirely wanting on the margin of the Cephalothorax. On the dorsal margin of the tibia of the male palpus the dorsal process is represented by a blunt tooth some distance from the margin and the area lying in front of it is not excavated as in the more typical forms. The embolic division of the genital bulb is aberrant for the group. The mesal tooth seems to be lacking and we have not been able to fully homologize the other teeth. The ventral process of the patella of the male palpus is represented merely by a blunt protuberance. While this species must be considered as a true Erigone, many of the characters have become so reduced that it must be looked upon as a highly aberrant member of the group.

## **Erigone whymperi** Cambridge

*Erigone whymperi* Cambridge. Ann. Mag. Nat. Hist. (Ser. 4) 20:276, pl. 8, fig. 2. 1877

? *Erigone longipalpis* Lenz. Bibliotheca Zool. Heft. 20, Leif. 3, p. 74. 1897

*Male.* Length, 3.5 mm. Cephalothorax grayish orange yellow, reddish toward the front and with radiating darker lines; viewed from above rounded at the posterior angles, the sides gently rounded and slightly constricted at the cervical groove, broadly rounded in

front; the margin armed with rather large teeth, two at the posterior angle, one large tooth opposite the second coxa, two large ones opposite the first coxa and after an interval, far forward are two more; a few smaller teeth scattered in the interval. Cephalothorax viewed from the side, rather low and gently arched behind to the cervical groove and then rounded over the head to the anterior median eyes. Clypeus slanting forward, in side view sinuate, depressed below the eyes, then convex, and concave towards the margin. Posterior eyes in a straight line, the median separated by the diameter and a little farther from the lateral. Anterior eyes in a straight line, the median larger than the posterior median, separated from each other by the radius and from the lateral by half as much more. Sternum dark brown, endites paler. Endites greatly thickened, armed on face with a number of rather strong tubercles. Chelicerae bluntly angulate externally above the stridulating area; the lateral row of teeth consisting of six or seven, the inner group of four or five; upper margin of the furrow armed with two large teeth, the larger one sinuate; between this and the base of claw are three or four minute blackish denticles; lower margin armed with three teeth, two close together near base of claw and a shorter one at an interval. Legs and palpi pale yellowish. Abdomen gray. A row of sharp teeth decreasing in size on upper anterior side of front femur. A large sharp tooth on same side of front trochanter and a smaller one on second.

Femur of palpus (figure 75) with a sharp bend at basal third and strongly curved downward at tip, armed ventrally at apex on the outer side with a large, thin recurved tooth and on the inner side with a very small one; armed on the under side with two rows of teeth: the outer row consists of a very low tooth near base, three large blunt teeth at the bend followed immediately by a short blunt tooth; the inner row consists of a short blunt tooth opposite the stridulating tooth, a long tooth before the bend, two long teeth at the bend, a long tooth after an interval and three smaller teeth about half way to the apex; inner face of femur armed with a row of about 12 small teeth decreasing in size, the first two only a little farther apart than the others. Patella long and slender at base, gradually thickened distally, the ventral process long, stout and somewhat recurved. Ratio of length of femur to that of patella as 46 to 26. Tibia long, slender at base and gradually widened distally, the dorsal line nearly straight when viewed from the side, armed on the ventral face with a short but distinct tooth. Dorsally at apex the tibia is armed with a high longitudinal ridge cut in the middle by a deep narrow notch and with the posterior angle elevated into a triangular tooth. Later-

ally from this ridge and beneath it the tibia is hollowed out into a deep pit. The embolic division is of the *hypenema* type but the median tooth is more slender and the posterior tooth more pointed and smooth.

*Female.* Length, 3.5 mm. Similar to male in color. The teeth on margin of cephalothorax greatly reduced in size being mere denticles. Chelicerae less robust than in male and the lateral teeth smaller; upper margin of the furrow armed with four large and one small teeth. Posterior eyes in a straight line, the median separated by the diameter and a little farther from the lateral. Anterior eyes in a straight line, the median separated by less than the radius and from the lateral by three-fourths the diameter. Epigynum transversely wrinkled, the posterior margin broadly emarginate; the edge upturned; the median tubercle transverse.

Greenland: Igaliko, 1 ♂ 1 ♀. (Zoological Institute, Copenhagen).

### Erigone zographica n. sp.

*Male.* Length, 2.3 mm. Cephalothorax dark grayish over orange yellow with darker radiating lines; viewed from above, rather broad, evenly rounded on the sides and broadly rounded across the front; viewed from the side, gently arched over the back to the cervical groove and then more steeply arched to the posterior eyes. Clypeus straight, slanting forward. Margin of cephalothorax armed with a row of small sharp teeth somewhat more regular than in most members of the genus.

Posterior eyes in a very slightly recurved line, separated by a little less than the diameter. Anterior eyes in a slightly procurved line, the median smaller than the lateral, separated by the radius and slightly farther from the lateral.

Chelicerae rather stout, rounded angulate laterally; the marginal row of teeth short, only half as long as the segment, composed of four or five rather strong, sharp teeth curving downward; on the inner margin a group of three or four small tubercles. Sternum and labium dark gray nearly black. Endites yellow orange, rather thickly studded except for a smooth area at base with tubercles. Legs and palpi yellowish. Abdomen dark gray.

Femur of palpus (figure 69) curved gently upward and inward at base, not bent, armed below with two rows of teeth; the outer row consists of six or seven small teeth, decreasing in size to small tubercles; the inner row consists of six slender teeth more or less uniform in size. Inner face of femur armed with a row of tubercles, the first one being only a little farther from the stridulating tooth than from the second tooth of the row. Tip of femur without a tooth

below. Patella slender at base, gradually thickened distally, the ventral process rather stout. Ratio of length of femur to that of patella as 31 to 15; ventral process of patella 6. Tibia slender at base and greatly widened distally, about as long as patella, ventral face armed with a low tooth. Dorsally at apex the lateral half is deeply excavated to form a large pit which is partly roofed over from the mesal side by a thin fold of integument; the edge of this fold is nearly straight with a sharp notch at the middle and the edge is continued posteriorly into a squarish point. In front of the pit, the margin of the tibia is thin, pointed toward the middle and obliquely truncate laterally. Embolic division (figures 76–77) of the *hypenema* type. The anterior tooth with a black sharp point, deeply grooved with the outside of the groove continued as a ridge along the mesal margin of the scaphium to the base of the posterior tooth. Median tooth large, transverse, flattened, somewhat twisted and strongly fluted. Posterior tooth a large thin transverse curved plate with a very deep rounded notch between it and the base of the scaphium; on the lateral angle there is a deep narrow fissure. It arises from a rather slender base and then widens out and becomes short scythe-shaped.

Holotype male. Artist's brook, Chapel pond, Essex county, N. Y.

New York: Artist's brook, Chapel pond, Essex county, June 28, 1923. 1 ♂.

Alberta: Lake Louise, Aug. 4, 1927, 1 ♂.

## THE AFFINITIES OF THE SPECIES OF ERIGONE

The relationship of the species may be roughly indicated by arranging them in the following groups.

The *psychrophyla* group, including: *hypenema*, *whymperi*, *labra*, *dentosa*, *metlakatla*, *olympias*, *aletris*, *zographica* and *ephala* of North America, *ourania* of China, *cristatopalpus*, *tirolensis* and *tenuimanus* of Europe. This group is characterized by the form of the dorsal margin of the tibia of the male palpus, which is excavated on the lateral half into a deep pit. This excavation is bounded on the inner side by a thin longitudinal ridge deeply incised near the middle. The embolic division has the middle tooth arising on the lateral side of the scaphium. This tooth is rather stout, it curves outward over the scaphium and has the tip fluted mesally and posteriorly. In *ourania* the middle tooth is greatly elongated.

The *atra* group, including: *arctica*, *arctophylacis*, and *alsaida* of North America, *siberica* of Asia and Alaska, and *capra* of Europe. The middle tooth of the embolic division is formed of the upturned edge of the scaphium and is of the so-called horseshoe-shaped form.

The tibia of the male palpus is deeply excavated all the way across dorsally at the tip and there is no longitudinal incised ridge. *E. dentigera* is related to this group in the form of the tibia but the posterior middle tooth of the embolic division seems to be lacking. In *alsaida* the excavation of the tip of the tibia is small.

The *autumnalis* group, including: *barrowsi* and *brevidentata.* In this group the femur is without teeth below or armed with a single small tooth (*autumnalis*). The median tooth is a thin longitudinal ridge.

Two species are not included in the preceding groups: *blaesa* in which the median tooth is crescent-shaped or boat-shaped, with two distinct points, and *tenuipalpus* an aberrant form.

## **Eperigone** new genus

Genotype: *Tmeticus trilobatus* Emerton
*Parerigone* Crosby and Bishop. Ent. Soc. Wash. 28:4. 1926 (in part)

In 1926 we established the genus Parerigone with *Erigone probata* Cambridge as type for this group of species. At that time we were following Emerton in identifying the common eastern species which he figured and described under that name with the true *probata* from Oregon. Since it has been shown that they are not the same and are not even closely related the name " Parerigone " must go with the type species and the present group is left nameless. We therefore propose " Eperigone " for it with *Tmeticus trilobatus* Emerton as type.

This genus is closely related to Erigone in the structure of the embolic division of the genital bulb of the male palpus. The posterior tooth of the embolic division is short, erect, and simple and not clothed with hairs or scales. It is not greatly prolonged and denticulate as in Catabrithorax Chamberlin. The patella of the male palpus is without the ventral process. In Eperigone the great development of spines on the chelicerae, margin of cephalothorax and on the male palpus is lacking except in *tridentata* Em., where there is a lateral row of teeth on the face of the chelicerae. This species is more closely related to Erigone than the others. In the female the epigynum is not of the Erigone type, but is trilobate.

### Key to the Species of Eperigone, Males

1 Chelicera without a prominent tooth on face.............................2
Chelicera with a prominent tooth on face..............................4
2 Tibia of palpus with dorsal margin truncate; armed back of margin with two small teeth.............................*entomologica* Emerton

Tibia of palpus with dorsal margin produced into a pointed process.......3

3 Emargination on lateral side of dorsal process of tibia with a distinct tooth near middle.......................................*indicabilis* n. sp.

Emargination without a distinct tooth near middle.........*index* Emerton

4 Chelicera with a lateral row of distinct teeth (not to be confused with minute setigerous tubercles).............................................5

Chelicera without a lateral row of distinct teeth........................6

5 Tibia with the dorsal margin produced into a lobe, rounded at tip, concave mesally and nearly straight laterally................*tridentata* Emerton

Tibia with the dorsal margin armed on the lateral side with a narrow process (figure 114)..................................*eschatologica* Crosby

6 Tibia deeply excavated dorsally and armed with a large process back of the excavation (figure 105).............................*contorta* Emerton

Tibia not of this form.................................................7

7 Dorsal margin of tibia armed with a broad process rounded at tip *trilobatus* Emerton

Dorsal margin of tibia truncated with the processes on the lateral angle...8

8 Three dorso-lateral processes...........................*maculata* Banks

With only two dorso-lateral processes...................................9

9 Embolic division with posterior tooth very short, not erect....*mniara* n. sp.

Embolic division with the posterior tooth large, erect..................10

10 Tibia armed with two strong processes, the inner one at the margin and the other farther back...............................*simplex* Emerton

Tibia with the dorso-lateral angle produced into a broad concave process ending in two rounded teeth separated by a rounded emargination *antrea* Crosby

## DESCRIPTIONS OF SPECIES OF EPERIGONE

### **Eperigone antraea** Crosby

*Parerigone antraea* Crosby. Ent. Soc. Wash. Proc. 28:4, pl. 1, fig. 4–6. 1926

*Male.* Length, 2 mm. Cephalothorax orange yellow; viewed from above, rather broad, rounded on the sides, the sides convergent toward the front with a slight constriction at the cervical groove, broadly rounded across the front. Viewed from the side evenly ascending along the back to the posterior eyes with only a very slight depression at the cervical groove and gently arched just back of the eyes. Clypeus straight, somewhat projecting.

Posterior eyes in a straight line, nearly equal in size and equidistant, separated by a little less than the diameter. Anterior eyes in a straight line, the median much smaller than the lateral, close together but well separated from the lateral. Just below the anterior median eyes are two long stiff hairs directed forward and curving upward.

Sternum smooth, sparsely clothed with short stiff hairs. Chelicerae with a prominent tooth on face at the inner angle and with a row of small setigerous tubercles on the outer margin. Legs and palpi light orange yellow. Abdomen probably gray (not in good condition).

Femur of palpus rather stout, armed below on the lateral side with a row of five or six spiniferous tubercles. Patella rather thick, curved downward. Ratio of length of femur to that of patella as 20 to 7. Tibia (figure 102) longer than patella, greatly widened distally, the dorso-lateral angle produced into a broad concave process which ends in two rounded teeth separated by a rounded emargination. Paracymbium rather stout, strongly curved basally, the distal part more nearly straight with a small sharp hook at tip. The embolic division (figures 103, 104) is boat-shaped, strongly curved upward in front and behind; the anterior tooth (*c*) recurved, sharp-pointed; the posterior tooth (*a*) stouter and more blunt. Between the two there is a thin longitudinal tooth (*b*) directed backward at the base of which lies a minute tubercle, the embolus. The mesal tooth rather short, bluntly rounded at apex. The median apophysis appears as a broad flattened curved process, the distal edge turned up into a sharp tooth like ridge, not shown in figure

*Female.* A little larger than the male. Epigynum a broad plate, transversely depressed, the sides convergent posteriorly and with the hind margin broadly and evenly concave with two rounded teeth projecting backward (figure 103 *a*). Between these teeth at a lower level there appears a blunt tooth.

New Mexico: Carlsbad cavern 1 ♂, 2 ♀.

This species shows no special adaptation to a life in darkness and probably lives near the opening of the cave.

### **Eperigone contorta** Emerton

*Tmeticus contortus* Emerton. Conn. Acad. Sci. Trans. 6:54, pl. 15, fig. 5. 1882

*Oedothorax contortus* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 311.

*Gongylidium undulatum* Emerton. N. Y. Ent. Soc. Jour. 22:263, pl. 8, fig. 4. 1914

*Parerigone contorta* Crosby. Ent. Soc. Wash. Proc. 28:4. 1926

*Male.* Length, 1.4 mm. Cephalothorax dusky orange, lighter back of the eyes, narrowly margined with dusky; viewed from above, rather long, evenly rounded on the sides, slightly convergent toward the front, rounded in front; viewed from the side, steeply ascending on the posterior declivity and then gently arched to the posterior eyes, highest just back of the posterior eyes. Clypeus slightly convex and nearly vertical.

Posterior eyes in a straight line separated by the diameter. Anterior eyes in a straight line, the median smaller than the lateral, separated from each other by the radius and from the lateral by the same distance. Clypeus nearly as wide as the median ocular area.

Sternum brown, broad, rounded on the sides behind and produced behind between the hind coxae. Hind coxae separated by less than their diameter. Labium same color as the sternum. Endites orange yellow. Legs and palpi orange yellow, the coxae somewhat dusky below, margin gray. Face of chelicera armed with a tooth in front and with a row of setigerous tubercles laterally on the face corresponding to the row of teeth in the typical Erigones. Abdomen very dark gray.

Femur of palpus long, slender, strongly curved and a little thickened distally, armed ventro-laterally on the basal half with a row of four stout hairs. Patella short, strongly curved ventrally and somewhat thicker distally. Ratio of length of femur to that of patella as 16 to 6. Tibia (figures 105–7) long, wide and strongly bent dorsally and excavated back of the insertion of the tarsus. The dorso-lateral apophysis is a thin, curved tooth, rounded at tip. On the outside near its base is a small pointed tooth. Cymbium strongly narrowed at base. Paracymbium a broad, thickly chitinized plate rounded at tip and with a rounded notch on the inside. The embolic division (figure 108) has the anterior tooth directed forward, long, stout, sharp-pointed and gently curved inward. From the mesal edge of the tooth a ridge extends along the edge of the scaphium to the base of the posterior tooth. The ejaculatory duct opens through a small tubercle on the lateral edge of the scaphium at the base of the anterior tooth. The posterior tooth is erect, long, pointed, rounded at tip. Mesal tooth rather stout, shorter than anterior tooth, bluntly rounded at tip.

Described from a specimen from Readville, Mass. We have 3 ♂ and 1 ♀ from Montauk Point, N. Y., in which the coloration is very much darker. The cephalothorax is greenish gray over yellowish and has a pattern of indistinct radiating lines. The abdomen is nearly black. The legs are decidedly dusky.

*Gongylidium undulatum* Em. appears to be merely a variety of *contorta*. In this form the dorsal tibial apophysis (figure 106) is longer and the embolic division seems larger. The structure of the latter, however, is the same in both forms.

Type localities: Cambridge and Waltham, Mass.

New York: Ithaca, May 19, 1924, 1 ♂. On ends of dried weeds at Renwick marsh; McLean, May 30, 1921, 2 ♂, June 21, 1924, 4 ♂ 5 ♀; Jamaica, Apr. 7, 1923, 1 ♂; East Hampton, May 24, 1924, 2 ♂ 2 ♀; Montauk Point, May 24, 1924, 4 ♂.

Massachusetts: Readville, Nov. 1918, 1 ♂ (Emerton).

### **Eperigone entomologica** Emerton

*Tmeticus entomologicus* Emerton. Conn. Acad. Sci. Trans. 16:395, pl. 3, fig. 3. 1911

*Parerigone entomologica* Crosby. Ent. Soc. Wash. Proc. 28:4, 1926

*Male*. Length, 1.1 mm. Cephalothorax dull dusky yellowish, with radiating lines; eye area black; viewed from above, rather broad, evenly rounded on the sides nearly to the front, bluntly rounded in front; viewed from the side, steeply ascending behind, very gently rounded over the head to the posterior eyes. Clypeus almost straight and slightly protruding.

Posterior eyes in a straight line, equal, the median separated by the diameter and from the lateral by the radius. Anterior eyes in a straight line, the median smaller than the lateral, separated by the radius and a little farther from the lateral. Clypeus a little narrower than the median ocular area.

Sternum greenish gray, darker at the margin, shrunken. Labium and endites pale yellowish. Abdomen light greenish gray. No tooth on face of chelicera.

Femur of palpus rather long, slender, rather strongly curved. Patella short, only moderately arched above. Ratio of length of femur to that of patella as 10 to 4. Tibia longer than the patella, widened distally. In a full back view (figure 112), the dorsal margin is squarely truncate, and the dorso-lateral angle is obliquely truncate, broadly and gently emarginate. When viewed diagonally along the axis of the tibia, the emargination appears to be armed with two small teeth (figure 111); in reality the teeth are a short distance back of the margin and appear only in profile when in the position noted above. Paracymbium broad, curved on the outside, straight on the inside and with a short hook at tip. The embolic division (figures 109–10) consists of a broad but short scaphium. The mesal projection not turned down but extending out on a level with the scaphium and bearing a rather large and blunt mesal tooth. The posterior tooth represented by the thin upturned margin of the scaphium; the anterior tooth, about midway between the posterior and mesal teeth, appears as a thin curved black-edged ridge from the tip of which there extends downward a smooth, bluntly pointed process.

*Female*. Length, 1.1 mm. Similar to male in form and color. The epigynum is a transverse plate, narrower in front, broadly and smoothly rounded behind, with a narrow raised rim along the edge.

Type locality: Ipswich and Tyngsboro, Mass.

New York: McLean, May 14, 1919, 4♂, June 13, 1922, 5♂ 5♀; Ringwood, Tompkins county, Oct. 11, 1920, 3♂ 1♀ in moss; Great pond, Riverhead, May 23, 1924, 1♂, Maratanza lake, Ulster county, May 24, 1920, 2♂; Little pond, Orange county, May 24, 1920, 1♂.

North Carolina: Top of Mount Mitchell, Oct. 22, 1923, 1♂ 2♀.

## **Eperigone eschatologica** Crosby

*Erigone eschatologica* Crosby. Calif. Acad. Sci. Proc. (ser. 4) 12:643, figs. 85–88. 1924

*Male.* Length, 2 mm. Cephalothorax light brownish-yellow, dusted with gray and with a very narrow marginal gray line, a black spot between and below the anterior median eyes; viewed from above, broad, with sides rounded and with the outline constricted at the cervical groove; viewed from the side, gently arched to the cervical groove, where there is a slight depression, and then gently rounded over the head to the eyes. Clypeus slightly protruding and gently convex near the margin. Posterior eyes in a straight or very slightly recurved line, separated by about their diameter, the median slightly closer to each other than to the lateral; anterior eyes in a straight line, equidistant, the median much smaller than the lateral.

Sternum gray over yellow. Hind coxae separated by less than their diameter. Endites yellow at tip and grayish at base, armed with only a few setigerous tubercles. Chelicerae reddish-brown, not so strongly convex as in many species of the genus; armed in front near the outer margin with a row of seven sharp teeth increasing in size from above, and on the front just above the furrow with a strong acute tooth. Legs and palpi light brownish-yellow; coxae light grayish below; legs distinctly hairy. Abdomen gray, lighter in front and marked behind with several transverse whitish bands. Ventral aspect of abdomen broadly gray in middle, with a light line on each side; epigastric plates yellowish, well separated by gray integument.

Femur of palpus moderately long and gently curved, not armed with teeth, but bearing on the ventro-lateral surface a row of four or five stiff hairs. Patella short. Tibia (figure 114) one and one-half times as long as patella, evenly enlarged from base to apex, armed above with an apophysis, convex on the mesal side and straight or gently concave laterally; outer side of this apophysis continuing the outline of the paracymbial echancrure of the tarsus. Paracymbium strongly curved, and ending in a small hook. The embolic division (figures 113, 115) consists of a short, stout, heavy scaphium, perpendicular and broadly rounded on the mesal side.

The anterior and posterior teeth of about equal length, erect and parallel; the posterior conical, acute; the anterior, transverse, thinner, the lateral edge minutely serrate. The ejaculatory duct[f] opens on a minute, thin, longitudinal ridge midway between the teeth. The above description of the embolic division is taken from a paratype.

In another specimen from Lower California, Puerto Escondido, June 14, 1921, which is light colored and had more recently moulted, the color pattern on the abdomen is more distinct. In front the abdomen is nearly white, with a median gray stripe which posteriorly joins a triangular transverse band; back of this is a broad whitish band narrowly interrupted in the middle; farther back are four narrow whitish bands, the last continuous with the light-colored area on the sides. Under side of abdomen gray with a large pale area in the middle.

*Female.* Length, 2.5 mm. Similar to the male in general coloration; abdomen marked much as in the light-colored male described above; there is, however, an indication of a transverse gray band across the light area on the front part of the abdomen. The usual teeth on the sides and on the inner angle of the chelicerae represented by setae borne on small tubercles. Epigynum (figure 116) consisting of a broad plate; on each side of the hinder half is a depression bounded in front by a smooth transverse ridge; hind margin broadly excised, bringing into view the rounded edge of an underlying lobe.

Mexico: San Marcos island, Gulf of California, June 19, 1921, 1♂ 1♀, Puerto Escondido, June 14, 1921, 1♂.

### **Eperigone index** Emerton

*Tmeticus index* Emerton. N. Y. Ent. Soc. Jour. 22:263, pl. 8, fig. 6. 1914
*Parerigone index* Crosby. Ent. Soc. Wash. Proc. 28:4. 1926

*Male.* Length, 1 mm. Cephalothorax dusky greenish yellow, darker at the margin, the eye area black; viewed from above, rather broad, evenly rounded on the sides to the front, bluntly rounded in front; viewed from the side, steeply ascending behind, flat on top. Clypeus straight and slightly protruding.

Posterior eyes in a slightly procurved line, equal, the median separated by the diameter and almost touching the lateral. Anterior eyes in a straight line, the median smaller than the lateral, equidistant, separated by radius of median. Clypeus a little narrower than the median ocular area.

Sternum greenish gray, large, convex, rounded on the sides, produced in a truncate point between the hind coxae which are sepa-

rated by nearly the diameter. Endites yellowish. Chelicerae without teeth on face. Legs and palpi yellowish-white. Abdomen dark greenish-gray with a few small light spots and broken longitudinal lines; ventral side uniform greenish-gray with the two usual longitudinal light lines.

Femur of palpus rather short, gently curved, slightly widened distally. Patella short and somewhat curved. Ratio of length of femur to that of patella as 11 to 4. The tibia (figures 118, 119) short, thick and gradually widened distally, the dorsal margin on the mesal half evenly rounded, armed near the margin with a high thin longitudinal ridge ending in a sharp black tooth. Laterally from this ridge there is a large, deep, rounded excavation. This cavity bounded behind by a curved ridge bearing a small blunt tooth near the middle, bounded in front by the evenly rounded and curved edge of the tibia continuous with the front edge of the longitudinal ridge. Paracymbium curved and hooked at tip. The embolic division (figures 117, 120) consists of a very broad triangular scaphium armed with a distinct stout mesal tooth. The posterior tooth long, erect, curved forward and spine-like in appearance. The anterior tooth is pale in color, rather long, and curved gently outward; at its base there is an elongate black tubercle on which is the opening of the ejaculatory duct$^f$. The median tooth is black, thin, elongate and beak-shaped and lies near the base of the anterior tooth.

*Female*. Length, 1.2 mm. Similar to male in form and color, abdomen lighter. Epigynum a broad protuberant lobe with the sides converging behind; posterior margin slightly emarginate.

Type locality: Freeville, N. Y.

New York: Howard, July 5, 1924, 2♂ 1♀; Prattsburg, July 16, 1926, 1♂ 2♀, in moss; Cinnamon lake, Schuyler county, July 12, 1924, 1♀, May 18, 1920, 1♂ 1♀; McLean, May 14, 1919, 6♂ 4♀; Ringwood, Tompkins county, May 20, 1919, 1♂ 1♀ (Dietrich); Suffern, Ramapo Mountains, May 26, 1924, 2♂ 6♀, in moss by pond (Helen Murray); Flushing, June 14, 1919, 1♂ in moss.

**Eperigone indicabilis** n. sp.

*Male*. Length, 1.1 mm. Cephalothorax dull honey yellow strongly suffused with dusky, darker toward the margin and along the radiating lines; viewed from above, broadly rounded on the sides with a very slight depression at the cervical groove, broadly and evenly rounded across the front; viewed from the side, rather low, moderately ascending behind, nearly level on the back, gently rounded over the head to the posterior eyes. Clypeus nearly straight,

slanting slightly forward. Posterior eyes in a slightly recurved line, the median separated by a little less than the diameter and a little nearer to the lateral. Anterior eyes in a slightly recurved line, the median smaller than the lateral, all separated by less than the radius of the median. Sternum nearly black with a few scattered minute yellowish spots at base of hairs, elongate, the sides nearly straight (possibly due to shrinkage). Posterior coxae separated by the diameter. Endites dusky honey yellow. Coxae and trochanters heavily marked with dusky. Chelicerae rather short and stout without teeth on the face. Legs honey yellow strongly suffused with dusky. Abdomen gray.

Femur of palpus nearly straight without ventral teeth. Patella short and nearly as thick as femur. Tibia (figures 121–23) longer than patella, widened distally, the sides in profile straight. The dorsal margin prolonged into a stout process directed diagonally outward. On the lateral side of this process the margin is doubly emarginate with a sharp tooth between the scallops. Paracymbium narrow basally, greatly widened distally with the notch at tip shallow. The embolic division (figures 124–26) consists of an oval, nearly flat scaphium. The anterior tooth is long, slender, black, spinelike, and nearly straight; at the base of this tooth on the mesal margin of the scaphium there is a thin sharp beaklike ridge. The posterior tooth is thin, broad, short, curved upward and the edge is notched. The mesal projection of the scaphium is elongate and bears a rather stout mesal tooth.

*Female.* Length, 1.2 mm. Similar to male. Epigynum a nearly flat plate, slightly depressed in the middle, the posterior margin broadly and evenly rounded.

New York: McLean, May 14, 1919, 2♂ 4♀.

### **Eperigone maculata** Banks

Not *Erigone probata* Cambridge. Zool. Soc. London Proc. 1874, p. 431, pl. 55, fig. 2

*Tmeticus probatus* Emerton. Conn. Acad. Sci. Trans. 6:52, pl. 15, fig. 1. 1882

*Gongylidium probatum* Simon. Ar. Fr. 5:500. 1884

*Erigone probata* Keyserling. Spinnen Amerikas, Theridiidae, 2:166, pl. 17, fig. 228. 1886

*Tmeticus maculatus* Banks. Phila. Acad. Nat. Sci. Proc. 1892, p. 41, pl. 4, fig. 23

*Oedothorax maculatus* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 311, 335

*Tmeticus probatus* Emerton. Conn. Acad. Sci. Trans. 14, pl. 4, fig. 1. 1909

*Tmeticus probatus* Banks. Phila. Acad. Nat. Sci. Proc. 1916, p. 75

*Parerigone probata* Crosby. Ent. Soc. Wash. Proc. 28:4. 1926

This common spider was identified by Emerton (1882) with *Erigone probata* Cambridge from Oregon. Dr A. Randall Jackson has kindly compared specimens from New York, which we sent him, with Cambridge's types at Oxford, and reports that they are quite distinct. We have therefore adopted for the species the next oldest name, *maculata* Banks.

*Male.* Length, 1.6 mm. Cephalothorax dusky orange with darker radiating lines; viewed from above, rather broad, evenly rounded on the sides, slightly convergent toward the front, bluntly rounded in front; viewed from the side, steeply ascending and gently rounded to the cervical groove where there is a distinct depression, then evenly curved over the head to the eyes. Clypeus concave and protruding.

Posterior eyes in a straight line, the median separated by about the diameter and a little closer to the lateral. Anterior eyes in a straight line, the median a little smaller than the lateral, all separated by the radius of the median. Clypeus a little narrower than the median ocular area. Sternum dark brown, rather broad, produced in a truncate point between the hind coxae which are separated by a little less than the diameter. Labium same color, endites dusky yellowish. A tooth on the face of chelicera. Legs and palpi dull yellowish. Abdomen dark gray with a double row of large light spots, under side dark gray with the two usual light lines.

Femur of palpus rather slender, rather strongly curved. Patella short, strongly arched above. Ratio of length of femur to that of patella as 20 to 5. The tibia (figures 127–28) opposite the paracymbium deeply excavated; the margin of this excavation is armed with three strong lobes, the basal and distal ones bluntly pointed, the distal one smaller, the middle one triangular. Paracymbium large, stout, rolled over, sharply angulate on the side farthest from the cymbium and with a very slight hook at the tip. The embolic division (figures 129–30) consists of a scaphium of very irregular shape; the anterior tooth is very short, triangular with the opening of the ejaculatory duct on a minute tubercle at its base $^{t}$. The median tooth is transverse, bluntly rounded at tip and projects mesally beyond the edge of the scaphium; laterally it extends as a ridge to the lateral edge where it ends in a point. The posterior tooth is stout, erect and bluntly rounded at tip. The edge of the scaphium is broad and perpendicular; anteriorly it is extended upward in a thin ridge and next to the anterior tooth there is a short tooth.

*Female.* Length, 1.8 mm. Usually a little lighter in color. The spots on the abdomen usually distinct. The epigynum (figure 131) consists of a broad transverse plate, rounded on the ends and emarginate behind. On each side in front, the openings occupy deep rounded emarginations in the plate *h*.

Type locality: Ithaca, N. Y.

New York: Wilmington notch, Essex county, Aug. 26, 1921, 1 ♀; Sylvan Beach, July 31, 1904, 1 ♂ 1 ♀; Wolcott, May 23, 1923, 1 ♀; Lake Bluff, Sept. 19, 1920, 1 ♀; Olcott, Sept. 1922, 1 ♀ (Dietrich), Oct. 1924, 2 ♀; Rock City, Cattaraugus county, Sept. 16, 1924, 1 ♀; Richburg, Sept. 16, 1925, 1 ♀; Italy hill, Oct. 1918, 1 ♀; Guyanoga, June 24, 1923, 9 ♂ 7 ♀; Lake Keuka, June 1904, 2 ♀, Dec. 1905, 2 ♀; Penn Yan, July 5, 1926, 7 ♂ 7 ♀; Barrington, Oct. 27, 1918, 1 ♀; Hammondsport, July 6, 1924, 1 ♀; Interlaken, July 1904, 2 ♂ 2 ♀; Taughannock falls, July 14, 1920, 1 ♂ 2 ♀; Connecticut hill, Tompkins county, Oct. 21, 1920, 1 ♀, Aug. 20, 1922, 1 ♀, Oct. 19, 1924, 1 ♀; Enfield glen, Tompkins county, June 4, 1922, 3 ♀, Aug. 6, 1922, 3 ♀; Ithaca, Aug. 1918, 1 ♀, Oct. 8, 1922, 1 ♀, July, 3 ♀, May, 1 ♀, July 12, 1925, 8 ♂ 6 ♀; Freeville, July 1 ♀; McLean, July 1904, 1 ♂ 1 ♀, July 4, 1924, 3 ♀, May 16, 1925, 1 ♀; Ringwood, Tompkins county, May 20, 1919, 1 ♀ (Dietrich); Deruyter lake, July 4, 1922, 1 ♀; Labrador pond, Cortland county, June 25, 1922, 2 ♀; Jenksville, Oct. 27, 1924, 1 ♀; Delaware lake, Delaware county, May 20, 1923, 2 ♂; Pearl point, Lake George, July 29, 1920, 4 ♀; Silver Bay, Lake George, Sept. 15, 1925, 1 ♀ (M. D. Leonard); Altamont, Apr. 12, 1924, 1 ♀; Mountainville, May 11, 1923, 3 ♀; Pinekill, Sullivan county, May 11, 1922, 2 ♀; Tuxedo, Oct. 4, 1925, 1 ♀ (A. Wolf); Pomona, Rockland county, Apr. 12, 1923, 2 ♀; Larchmont, Sept. 26, 1925, 1 ♂ 7 ♀ (A. Wolf); Clove Valley, S. I., Nov. 16, 1918, 2 ♀; Sea Cliff, Sept. 6, 1925, 1 ♀ (Wolf & Taub); Riverhead, May 31, 1923, 1 ♀, Aug. 11, 1923, 1 ♀; Long pond, Suffolk county, June 29, 1924, 2 ♂ 3 ♀; Great pond, Riverhead, May 23, 1924, 1 ♂ 1 ♀; Baiting hollow, May 23, 1924, 1 ♂, May 31, 1923, 2 ♂ 3 ♀; Sound beach, Riverhead, Sept. 10, 1922, 1 ♂; Southold, April 11, 1923, 1 ♂; Amagansett, May 24, 1 ♂ 1 ♀; Montauk Point, May 24, 1924, 1 ♂.

Maine: Bridgeton, Aug. 22, 1925, 1 ♀.

New Hampshire: Hollis, Aug. 1888, 1 ♂; Meredith, Aug. 22, 1925, 1 ♀; L. Winnepesaukee, May 29, 1906, ♂ (Bryant).

Connecticut: New Haven, Oct. 15, 1880, ♂ ♀ (Emerton).

Massachusetts: Brookline, May 1, 1906, 1 ♀; Blue hills, Apr.–May (Bryant); Clarendon hills, Nov. 10, 1904, ♂ (Bryant); Magnolia, Apr. 19, 1906, ♂ (Bryant); Waltham, Nov. 9, 1906, ♂ (Bryant).

Pennsylvania: Roxbury, Oct. 30, 1924, 1 ♀.

District of Columbia: June, 2 ♀.

Virginia: Great Falls, April 3, 1921, 1 ♀; Covington, Sept. 1905, 2 ♀.

North Carolina: Blowing Rock, Oct. 10, 1923, 5 ♀; Wayah Bald, Macon county, Oct. 16, 1926, 1 ♂; Minehole gap, Buncombe county, Oct. 17, 1923, 1 ♀; Montreat, Oct. 16, 1923, 1 ♀; Mount Pisgah, Oct. 19, 1923, 1 ♂.

Georgia: Billys island, Okefinokee Swamp, June 1912, 2 ♂ 4 ♀; Thunderbolt, April 1911, 1 ♂.

Florida: Gainesville, 1 ♀; Dunedin, Dec. 1925, 1 ♂ (Blatchley); Florahome, Mar. 8, 1927, 1 ♂ 1 ♀ (Leonard); Tallahassee, Apr. 13, 1927, 1 ♀; Micanopy, Mar. 6, 1927, 1 ♀ (Barrows); Monticello, Apr. 6, 1927, 1 ♀ from sphagnum (F. Walker), April 7, 1927, 1 ♂ (F. Walker); Rock Bluff Landing, Appalachicola river, Apr. 4, 1927, 1 ♂ 1 ♀ (Hubbell).

Tennessee: Beersheba, July 1 ♂ (Fox).

Kentucky: Quicksand, June 25, 1925, 5 ♀.

Mississippi: Meridian, ♂ (Banks).

Illinois: Urbana, July 27, 1 ♀, Aug. 17, 1925, 1 ♂, June 29, 1926, 1 ♀, Feb. 22, 1926, 2 ♀; Brownfield, May 8, 1 ♂ 3 ♀, June 8, 1926, 1 ♀, June 21, 1926, 1 ♀ (All collected by Miss V. G. Smith).

Minnesota: Lake Minnetonka, July 17, 1924, 1 ♂, July 31, 1924, 1 ♀, Aug. 9, 1924, 1 ♂ 2 ♀, Aug. 28, 1924, 1 ♀, Sept. 1924, 4 ♀, June 22, 1926, 1 ♂ 1 ♀, June 30, 1926, 1 ♂ 2 ♀ (All collected by F. C. Fletcher).

Missouri: Columbia, Nov., 10 ♂ 3 ♀, Mar. 1906, 1 ♂, Nov., 1 ♀, Oct. 2 ♂ 2 ♀, Nov. 22, 1904, 1 ♂ 2 ♀, Dec. 1904, 1 ♂, Nov. 24, 1904, 2 ♂ 2 ♀, Nov. 1904, 1 ♀, July 1 ♀; Mansfield, Oct. 1905, 1 ♀.

Arkansas: Hope, May 21, 1926, 1 ♀ (Knobel).

Kansas: Blue Mound, Douglas county, 1924, 3 ♂ 2 ♀ (Beamer).

### **Eperigone mniara** n. sp.

*Male.* Length, 1.6 mm. Cephalothorax dull grayish yellow; viewed from above, rather long, evenly rounded on the sides, convergent toward the front, broadly rounded in front, the eyes projecting beyond the edge; viewed from the side, rather steeply ascending to the dorsal groove, then rounded over to the posterior eyes, highest behind the eyes. Clypeus straight and almost vertical.

Posterior eyes in a straight line, equal, equidistant, separated by a little less than the diameter. Anterior eyes in a straight line, the median smaller than the lateral, equidistant, separated by the radius

Clypeus as wide as the median ocular area. Sternum greenish-yellow, convex, shining, a little longer than broad, rounded on the sides, convergent behind, produced behind in a truncated point between the hind coxae which are separated by half the diameter. Endites dusky orange yellow. Chelicerae dusky orange yellow with a tooth on the face. Legs and palpi dingy yellowish. Abdomen grayish-yellowish to dark greenish gray.

Femur of palpus rather stout, moderately long and curved, armed on the ventral side with five long slender hairs. Patella rather short and widened distally. Ratio of length of femur to that of patella as 20 to 7. Tibia (figure 133) longer than patella, swollen distally. The dorsal margin thin, and gently concave, the margin on the dorso-lateral angle is also thin and produced into a broad rounded lobe with a small nipplelike projection lying over the lateral edge of the cymbium. Back from the margin there is a prominent, blunt, erect, toothlike process. Paracymbium rather long, curved upon itself, with two rounded lobes at the tip. The embolic division (figures 132, 134) consists of a semicircular plate with the lateral margin straight. The anterior tooth is black and sharp with a groove that extends lengthwise of the scaphium with both the inner and outer edges raised in ridges; the posterior angle of scaphium is turned upward and bluntly pointed. The ejaculatory duct opens on the anterior tooth $^{f}$. The mesal margin of the scaphium is turned toward the edge of the cymbium and provided with a distinct mesal tooth. The median apophysis appears as a conspicuous black, blunt, erect, process between the bezel and the embolus.

*Female*. Length, 1.6 mm. Similar to male in form and color. Epigynum (figure 135) a large lobe a little longer than wide, broadly rounded behind with a narrow slit in the middle; on each side of the slit there is a sharp angle and laterad of that the margin is folded so as to give a double edge. Base of epigynum transversely wrinkled.

Holotype male; allotype female.

Colorado: Pingree park, Larimer county, 9000 feet, Aug. 20, 1924, 43♂ 43♀, in moss around pond.

### **Eperigone simplex** Emerton

*Tmeticus simplex* Emerton. Conn. Acad. Sci. Trans. 18:216, pl. 2, fig. 3. 1913

*Parerigone simplex* Crosby. Ent. Soc. Wash. Proc. 28:4. 1926

*Male*. Length, 1.7 mm. Cephalothorax pale yellow suffused with gray; viewed from above, rounded on the sides, truncate across the front with the head projecting forward so that the anterior

median eyes appear in profile in front of the clypeus; viewed from the side, steeply ascending behind, then more gradually to the eyes. Clypeus nearly vertical, concave. Posterior eyes in a straight line, the median separated by a little less than the diameter and a little nearer to the lateral. Anterior eyes in a slightly procurved line, the median a little smaller than the lateral, all separated by about the radius of the median. Chelicerae yellowish, armed on the face near inner angle with a large tooth and with a row of minute setigerous tubercles along lateral edge. Sternum dark gray, black at margin. Endites yellowish suffused with dusky. Legs and palpi pale yellow, coxae below dusky, narrowly black at tip. Abdomen gray.

Femur of palpus compressed, viewed from the side nearly straight, gently curved inward. Patella short, as long as thickness of femur. Ratio of length of femur to that of patella as 26 to 7. Tibia (figure 138) very large, viewed from the side wider than long, dorsally armed with two strong processes, the inner one at the margin and the other farther back; ventral notch in margin distinct but not deep. Paracymbium broad and thick basally, hook short. Embolic division (figures 136, 137) consists of a distinctly concave scaphium; the anterior tooth is long, erect, black and ends in a long sharp point directed anterio-laterally. The posterior tooth is large, stout, erect and pointed at tip. The mesal projection of the scaphium is broad and rounded, with the mesal tooth short, stout, rounded at tip and lying far forward. The ejaculatory duct [f] opens on a small black pointed tubercle at the base of the anterior tooth.

Type locality: Middleboro, Mass.

New York: Little pond, Orange county, May 25, 1920, 1♂.

## **Eperigone tridentata** Emerton

*Tmeticus tridentatus* Emerton. Conn. Acad. Sci. Trans. 6:53, pl. 15, fig. 2. 1882

*Erigone tridentata* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 340

*Erigone tridentata* Crosby. Can. Ent. 37:367, 1905

*Erigone clarksvillense* Petrunkevitch. N. Y. Ent. Soc. Jour. 33:172, pl. 8, figs. 3, 4. 1925

*Male.* Length, 2.3 mm. Cephalothorax grayish orange yellow with darker radiating lines, front part of head lighter; viewed from above, evenly rounded on the sides, slightly constricted at the cervical groove and broadly rounded across the front. No marginal row of teeth. Cephalothorax viewed from the side, rather steeply ascending behind, then more gradually to the eyes, the head not abruptly elevated. Clypeus straight, slanting forward.

Posterior eyes in a straight line, equal and equidistant, separated by a little less than the diameter. Anterior eyes in a procurved line, the median smaller than the lateral, separated from each other by a little more than the radius and from the lateral by the radius.

Chelicerae orange yellow divaricate at tip, armed laterally with a row of six strong teeth curving downward; at the inner angle there is a large downward projecting tooth. Claw long and slightly sinuate. Sternum grayish yellow, lighter in front. Posterior coxae separated by less than the diameter. Endites light orange yellow, nearly smooth with a few scattered setigerous tubercles. Legs and palpi pale orange yellow. Abdomen pale in front, marked with a median grayish stripe and posteriorly with four transverse grayish bands; underside grayish, paler in middle.

Femur of palpus (figure 142) gently curved inward and armed ventro-laterally with a row of five or six small setigerous tubercles. Patella short and thick, curved downward. Ratio of length of femur to that of patella as 40 to 15. Tibia longer than patella obconical in outline, the dorsal margin produced into a lobe concave mesally and nearly straight laterally, the tip rounded. Paracymbium viewed from the side broadly lunate with a stout hook at tip. Embolic division (figures 139, 140) viewed from below, U-shaped with the mesal tooth strongly developed, blackish at tip and lying nearly parallel to the anterior tooth. Anterior tooth a large, stout, black, beaklike process which mesally is continued as a ridge along the edge of the scaphium. The median tooth stout, curved mesally and ending in three blunt points. Posterior tooth a stout, brownish, erect, pointed process. The median apophysis appears as a quadrate process with acute corners.

*Female*. Length, 2.3 mm. Similar to the male in form and color. Posterior median eyes a little nearer each other than to the lateral. Anterior eyes in a straight line, the median smaller than the lateral, nearer to each other than to the lateral. Chelicerae normal in form, the lateral row of teeth represented by a series of five or six minute tubercles. Endites not so greatly thickened as in male. Epigynum (figure 141) a broad plate deeply and broadly notched behind, disclosing a middle lobe; the margin of the notch with a distinct tooth in front of the middle; the middle lobe rounded behind with a rounded excavation in the margin on each side and provided with a black median longitudinal ridge.

Type localities: Providence, R. I. and New Haven, Conn.

We have examined the types of *Erigone clarksvillense* Petrunkevitch, two females. In each the epigynum is badly gummed. We

removed the epigynum from one and cleaned it in caustic potash. We then found it to agree exactly with *tridentata*. We designate this specimen as the lectotype.

New York: Lake Keuka, Sept. 1903, 1 ♀; Ithaca, Nov. 1 ♀; Rensselaer, Nov. 19, 1921, 1 ♀, (Schoonmaker); Clove valley, Staten Island, Nov. 16, 1918, 1 ♂; Sea Cliff, several specimens (Banks).

Massachusetts: Readville, Nov. 6, 1913, 4 ♂ (Emerton); Blue Hills, Nov. 28, 1914, 3 ♂ (Emerton).

District of Columbia: Washington, July 12, 1925, 1 ♂ (Barber); May, 2 ♂ (Fox).

Ohio: Old Man's cave, Aug. 7, 1924, 1 ♂ 1 ♀ (Barrows).

Illinois: Salts, Oct. 11, 1925, 1 ♂ (Smith).

Tennessee: Clarksville, 1921, 2 ♀ (Crumb). Types of *Erigone clarksvillense* Petrunkevitch.

Missouri: Rochport cave, Dec. 30, 1904, 1 ♂ 1 ♀. On driftwood in total darkness.

Louisiana: Shreveport, 2 ♂ 1 ♀ (Banks).

### **Eperigone trilobata** Emerton

*Tmeticus trilobatus* Emerton. Conn. Acad. Sci. Trans. 6:53, pl. 15, fig. 4. 1882

*Tmeticus moestus* Banks. Phila. Acad. Nat. Sci. Proc. 1892, p. 40, pl. 4, fig. 19

*Tmeticus palustris* Banks. Phila. Acad. Nat. Sci. Proc. 1892, p. 40, pl. 4, fig. 21

*Tmeticus gnavus* Banks. Phila. Acad. Nat. Sci. Proc. 1892, p. 41, pl. 5, fig. 44

*Oedothorax trilobatus* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 313, 337

*Gonglydium* (sic) *trilobatus* Banks. Phila. Acad. Nat. Sci. Proc. 1916, p. 75

*Parerigone trilobata* Crosby. Ent. Soc. Wash. Proc. 28:4. 1926

*Male.* Length, 1.6 mm. Cephalothorax dusky orange-yellow, with dusky radiating lines and margin; viewed from above, rather broad, evenly rounded on the sides almost to the front, rounded in front, the eyes projecting beyond the front edge; viewed from the side, rather steeply rounded to the dorsal groove where there is a slight depression, then gently rounded over to the posterior eyes, highest just behind the eyes. A median row of long hairs directed forward on the head. Clypeus almost vertical and slightly concave.

Posterior eyes in a straight line, equal and equidistant, separated by a little less than the diameter. Anterior eyes in a straight line, the median smaller than the lateral, the median separated by the diameter and from the lateral by the radius. Clypeus a little narrower than median ocular area. An erect bristle on the middle of the clypeus. A tooth on the face of the chelicera.

Sternum dusky brownish yellow, rather broad, convex, rounded on the sides and produced as a truncated point between the hind

coxae which are separated by a little less than the diameter. Legs and palpi dingy yellowish-white. Abdomen grayish-yellow.

Femur of palpus moderately long and rather strongly curved. Patella short and strongly arched above. Ratio of length of femur to that of patella as 15 to 5. Tibia (figure 145) short, compressed, the dorso-lateral apophysis broad, rather long, obliquely truncated laterally, rounded at tip. The lateral margin is folded under to form a broad, rounded plate which is not visible when viewed from above. The ventral margin is armed with two long blunt pointed teeth. Paracymbium broad, the inner margin nearly straight with a hook at the tip. The embolic division (figure 146) consists of an oval scaphium. The mesal tooth is short and thick; the anterior tooth long, stout, black and sharp-pointed, directed forward; posterior tooth pale, stout, long, erect and blunt-pointed. The ejaculatory duct (*f*) opens on a rather high thin tubercle at the base of the anterior tooth, the edge of this tubercle is inverted V-shaped and the opening is at the apex. The median apophysis appears as a pointed black tooth near the distal edge of the bezel.

In a specimen expanded artificially but in an approximately natural manner the anterior tooth of the embolic division is directed backward into the cavity laterad of the dorsal ridge of the tibia and the tubercle bearing the opening of the ejaculatory duct lies near the edge of the tibia. The posterior tooth stands erect close to the edge of the cymbium directly in front of the dorsal process of the tibia.

*Female*. Length, 1.6 mm. Similar to male in form and color. The epigynum (figure 144) consists of two lateral lobes, the inner margins of which are parallel. Each lobe is strongly curved downward, strongly carinate and rounded at tip. Between these lobes the bluntly pointed middle lobe can be seen.

Type localities: Cambridge, Mass. and New Haven, Conn.

New York: Trenton Falls, June 5, 1921, 1♂; Olcott, Sept. 1922, 1♂ (Dietrich); Lockport, Nov. 1918, 1♀; Cinnamon lake, Schuyler county, July 12, 1924, 1♀; Ithaca, Nov., 1♀, Mar., 1♂, April 21, 1926, 1♂; Freeville, Oct. 12, 1924, 1♂; Ringwood, Tompkins county, May 20, 1919, 1♂ (Dietrich); Albany, July 23, 1916, 2♂ 1♀; Voorheesville, June 19, 1923, 1♂; Normansville, July 1916, 1♀; Clove Valley, S. I., Nov. 16, 1918, 1♂; Cold Spring Harbor, Apr. 9, 1905, ♂ (Bryant); Lloyds Neck, July 31, 1907, ♂ (Bryant); Sea Cliff, ♂ (Banks); Jamaica, Apr. 7, 1923, 1♂ 1♀ (A. Wolf); Little pond, Orange county, May 25, 1920, 1♀.

Maine: Machias, Aug. 1913, ♀ (Emerton).

New Hampshire: Lake Winnepesaukee, May 29, 1906, ♂ (Bryant).

Massachusetts: Boston, June 4, 1904, ♂ (Bryant); Blue hills, Apr. 25, 1906, ♂ (Bryant); Brookline, May 1, 1906, Nov. 8, 1904, ♂ (Bryant); Duxbury, June 4, 1921, ♂ (Bryant); Readville, Nov. 6, 1913, ♂ (Emerton).

District of Columbia: May, 1♂, Nov., 2♂ (Fox); Washington, ♂ (Banks).

Virginia: Falls Church, ♂ (Banks); Great falls, ♂ (Banks).

Georgia: Billys island, Okefinokee swamp, June 1912, 2♀.

Illinois: Salts, Aug. 21, 1926, 1♀ (Smith).

Missouri: Columbia, July, 1905, 2♂, Nov. 1904, 3♂ 5♀, Dec. 1904, 1♂; no date, 2♂ 1♀.

This species has also been recorded by Emerton from Quebec: Maniwaki; British Columbia: Laggan.

## Catabrithorax Chamberlin

Can. Ent. 52:198. 1920
Type: *C. clypiellus* Chamberlin
*Montilaira* Chamberlin. N. Y. Ent. Soc. Jour. 29:40. 1921
Type: *Hilaira uta* Chamberlin

This genus is closely related to Erigone and Eperigone in the general structure of the embolic division of the bulb, but may be distinguished by the extreme development of the posterior tooth. It is very long, curved forward and appears as a conspicuous structure on the ventral side of the bulb. In *clypiellus* it reaches its greatest length extending forward to or beyond the tip of the bulb; in *ksenius*, *probatus*, *perplexus*, *utus* and *pertinens* it is armed towards the tip with flattened spines or scalelike teeth; in *plumosus* it is hairy and in *oxypaederotipus* it is branched. We unite Montilaira with Catabrithorax because the only essential difference seems to be the greater development of the posterior tooth of the embolic division. It is quite probable that other species may be found in which the length of this tooth is intermediate.

### Key to the Species of Catabrithorax, Males

1 Chelicera without tooth on face . . . . . . . . . . 2
Chelicera with a tooth on face . . . . . . . . . . 4
2 Posterior tooth of embolic division branched . . . . . . . . *oxypaederotipus* Crosby
Posterior tooth simple, unbranched . . . . . . . . . . 3
3 Posterior tooth of embolic division extremely long, extending to or beyond the tip of bulb . . . . . . . . *clypiellus* Chamberlin
Posterior tooth shorter, not reaching tip of bulb . . . . . . . . *plumosus* Emerton

4 Dorsal margin of tibia of palpus without a distinct tooth . . . . . . . . . . . . . . . . 5
Dorsal margin of tibia with a distinct tooth or process . . . . . . . . . . . . . . . . . . 6
5 Margin of tibia with a shallow notch on the inner side . . . . . *utus* Chamberlin
Margin of tibia with a deep notch on inner side . . . . . . . *perplexus* Keyserling
6 Dorsal margin of tibia armed with two small teeth close together (figure 87) *pertinens* Cambridge
Dorsal margin of tibia armed with a single large median tooth and laterally with a rounded lobe (figure 81) . . . . . . . . . . . . . . . . . . . . . . . . . *ksenius* n. sp.
Dorsal margin not so armed . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7
7 Dorsal margin of tibia with a broad process, pointed laterally, and rounded mesally (figure 89) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *probatus* Cambridge

## DESCRIPTIONS OF SPECIES OF CATABRITHORAX

### **Catabrithorax clypiellus** Chamberlin

*Catabrithorax clypiellus* Chamberlin. Can. Ent. 52:199, figs. 1–3. 1920
*Catabrithorax ceuthus* Chamberlin. Can. Ent. 52:200. 1920

*Male.* Length, 1.6 mm. Cephalothorax broad and rather flat, evenly rounded on the sides, light brownish-yellow in color. Posterior eyes in a straight line, rather large and close together, nearly equidistant. Anterior eyes in a straight line, equidistant and very close together, the median smaller than the lateral. The clypeus in the type specimen is only about as wide as the diameter of an anterior median eye. This we believe is abnormal. The chelicerae seem to have been forced upward and bent backward. As evidence that this is the case it is to be noted that the striations on the side of the chelicerae are partly covered by the sides of the cephalothorax. Chelicerae clear brownish yellow without a tooth on face. Sternum broadly gray on the sides, light in the middle; front margin straight, sides rounded. Hind coxae separated by less than their length. Legs and palpi light brownish yellow. Abdomen light gray. Coxae visible from above.

The embolic division of the palpal organ has the posterior tooth extremely long, slender and curved forward so that its tip lies farther forward than other parts of the bulb (figures 78–80). As specimens were not available for boiling it was not possible to study carefully the other parts of the embolic division.

Type localities: of *clypiellus*, Logan canyon, Utah; of *ceuthus*, Bear lake, Utah.

### **Catabrithorax ksenius** n. sp.

*Male.* Length, 2.7 mm. Cephalothorax dull yellowish-orange to dark reddish-brown with radiating lines, rather elongate with the sides evenly rounded and converging in straight lines toward the

front, not constricted at the cervical groove; head rather narrow, broadly rounded in front. Cephalothorax viewed from the side, steeply ascending and somewhat convex in outline on the posterior declivity, then more gradually ascending and gently concave to the top of the head which is considerably back of the posterior median eyes, armed with a median row of rather long forward directed hairs. Clypeus nearly straight and projecting slightly forward.

Posterior eyes in a straight line, the median separated by the diameter and a little farther from the lateral. Anterior eyes in a straight line, the median smaller than the lateral, almost touching but separated from the lateral by nearly the diameter. Chelicerae yellow orange, armed on the face at the inner angle with a distinct tooth. Sternum and labium dark gray; endites yellow. Legs and palpi light yellow. Abdomen light to dark gray.

Femur of palpus only slightly curved but distinctly thicker distally. Patella shorter than tibia. Tibia (figures 81, 83) short and broad; the dorsal margin armed in the middle with a prominent tooth, laterally from this tooth there is a shallow rounded notch and a semi-transparent, rounded upturned lobe; mesally from the tooth there is a somewhat deeper but fairly shallow rounded notch the edge of which is not thickened as in *uta*. Paracymbium broad at tip, with a deep rounded notch and a distinct hook. The embolic division (figure 82) consists of a scaphium of elongate but irregular form. The posterior tooth is greatly developed; it is broad, thin, very long and curved forward over the scaphium nearly to the anterior tooth; it is pointed at tip and on the mesal side some distance from the tip is armed with a group of long, sharp, overlapping, flattened spines; the tip is armed on the mesal half with similar spines but they are very much smaller. Across the middle of the scaphium there is a diagonally transverse ridge which bears a row of black spines, the lateral one much longer than the others. The anterior end of the scaphium is turned upward to form a broadly rounded prow, or anterior tooth. At the base of this tooth on the mesal side is a thin sharp-pointed tooth directed backward and inward on the lateral side of which the ejaculatory duct opens [f].

This species is obviously related to *Catabrithorax probatus* Cambridge (not *Tmeticus probatus* Emerton) which it resembles in size, color and structure of the palpus. It differs markedly from *C. probatus* in the structure of the tibia of the palpus which in *C. ksenius* is armed on the dorsal margin with a single prominent tooth, laterad of which there is a rounded upturned lobe, and mesally with a broad, shallow notch. In *C. probatus* the dorsal margin of the tibia is pro-

duced into a broad, shallowly emarginate plate and mesally there is a gibbous, almost semicircular projection (figure 89).

Dr A. Randall Jackson of Chester, England very kindly compared the type of *C. ksenius* with the type of *probatus* Cambridge and furnished the sketches of the palpal tibiae of both *ksenius* and *probatus*.

Holotype male. Metlakatla, British Columbia. In the Museum of Comparative Zoology there are several additional specimens probably of this species.

British Columbia: Metlakatla, 1 ♂.

Washington: Paradise Camp, Mount Rainier, Aug. 17, 1927, 1 ♂, 6500 feet, near snow.

### **Catabrithorax oxypaederotipus** Crosby

*Oedothorax oxypaederotipus* Crosby. Phila. Acad. Nat. Sci. 1905, p. 336, pl. 38, fig. 9, 15

*Tmeticus aestivalis* Emerton. Conn. Acad. Sci. Trans. 16:394, pl. 3, fig. 1. 1911

*Male.* Length, 1.2 mm. Cephalothorax greenish-gray with darker radiating lines; viewed from above, broadly oval, rounded on the sides, converging toward the front, broadly rounded in front; viewed from the side, gradually ascending and rounded over to the posterior eyes. Clypeus straight and nearly vertical.

Posterior eyes in a straight line, equal, equidistant, separated by a little less than the diameter. Anterior eyes in a straight line, the median smaller than the lateral, subcontiguous, separated from the lateral by the diameter. Clypeus as wide as ocular area. Sternum greenish-gray, darker at the margin. Labium and endites dull yellowish. Abdomen gray with the usual two light lines beneath. Legs and palpi dull yellow to almost white. No tooth on face of chelicera.

Femur of palpus rather long, slender, gently curved. Patella short and arched above, a little thicker than the femur. Ratio of length of femur to that of patella as 16 to 5. Tibia (figure 92) longer than patella and strongly widened distally, the margin deeply excavated leaving two lobes; the dorso-lateral lobe, viewed from above, is a square-tipped process with a notch on the outer distal angle; viewed from the side, rectangular. The dorsal lobe is longer, curved, broad at base and bluntly rounded at tip. The paracymbium very large, rolled over toward the cymbium, the edge with a deep rounded notch near tip. The embolic division (figure 93) consists of an elongate comparatively narrow scaphium. The anterior tooth is black and beak-shaped. The median tooth is a black, diagonally transverse ridge, rounded laterally with a square

point mesally; from its mesal end a low, black ridge extends to the edge of the scaphium. The posterior tooth (figure 91) is enormously developed; it is slender at base but soon divides into two very long branches, the lateral branch more slender and smooth, the mesal one thickened medially, its surface minutely striate with a small tooth at the distal end of each ridge on the anterior surface. The mesal surface of the scaphium comparatively narrow, provided with a distinct incurved mesal tooth.

*Female.* Length, 1.2 mm. Colored as in the male, abdomen much wider. Epigynum a convex lobe broadly rounded behind; the inner parts show through the integument very distinctly.

Type locality: Ithaca, N. Y.

New York: Old Forge, Oct. 24, 1922, 1 ♀ ; Little Valley, Sept. 17, 1925, 1 ♀ ; Clarksburg, Sept. 18, 1925, 1 ♀ ; Ceres, Sept. 16, 1925, 1 ♀ ; Letchworth park, July 9, 1922, 1 ♂ 2 ♀ ; Guyanoga, June 24, 1923, 14 ♀ ; Penn Yan, May 30, 1923, 14 ♂ ; Lake Keuka, April 1904, 1 ♂ , Dec. 1 ♀ , June 1904, 4 ♀ ; Taughannock falls, July 14, 1922, 2 ♀ ; Connecticut hill, Tompkins county, Aug. 20, 1922, 1 ♀ ; Ithaca, May, 15 ♂ , Oct., 1 ♀ , Feb., 1 ♀ , July, 1 ♀ ; July 12, 1925, 5 ♀ ; Freeville, May 1911, 1 ♂ , July 1904, 5 ♀ , Oct. 12, 1924, 1 ♀ ; McLean, May 8, 1919, 1 ♂ , July 4, 1924, 2 ♀ ; May 16, 1925, 1 ♂ ; Ringwood, Tompkins county, May 20, 1919, 1 ♂ (Dietrich); Slaterville, May 10, 1925, 1 ♀ ; Danby, Oct. 18, 1924, 1 ♀ ; Deruyter lake, July 4, 1922, 1 ♀ ; Labrador pond, Cortland county, June 25, 1922, 2 ♀ ; Belden hill, Broome county, May 19, 1923, 15 ♂ 5 ♀ . There were many immature specimens taken at this time and the species seemed to be just reaching maturity; West Windfield, June 8, 1921, 1 ♀ ; Meredith, May 19, 1923, 5 ♂ 1 ♀ ; Delaware lake, Delaware county, May 20, 1923, 14 ♂ 5 ♀ ; Apalachin, May 19, 1923, 2 ♂ ; Trenton Falls, June 5, 1921, 1 ♀ ; Altamont, April 12, 1924, 1 ♀ ; Mount Utsayantha, Delaware county, Oct. 21, 1924, 1 ♀ ; Slide mountain, Ulster county, May 8, 1921, 2 ♂ 5 ♀ ; Paradise, Orange county, May 26, 1920, 1 ♂ ; Oakland Valley, May 26, 1920, 1 ♂ 1 ♀ .

Pennsylvania: President, July 3, 1922, 1 ♀ (Palmer); Potters Mills, Oct. 31, 1924, 1 ♀ .

This species has also been recorded by Emerton from Massachusetts: Mount Toby, Holden.

## **Catabrithorax perplexus** Keyserling

*Erigone perplexa* Keyserling. Spinnen Amerikas, Theridiidae 2:190, pl. 17, fig. 250. 1886

*Tmeticus pectinatus* Emerton. Conn. Acad. Sci. Trans. 9:409, pl. 2, fig. 4. 1894

*Tmeticus perplexus* Banks. Phila. Acad. Nat. Sci. Proc. 1901, p. 580, pl. 33, fig. 7

*Oedothorax perplexus* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 312

*Gongylidium perplexus* Emerton. Royal Can. Inst. Trans. 12:316. 1919

*Male*. Length, 3.6 mm. Cephalothorax dark reddish brown; viewed from above, rather broad evenly rounded on the sides, convergent toward the front, rounded in front; viewed from the side, evenly rounded over the back to the posterior eyes, highest back of the eyes. Clypeus straight and somewhat protruding.

Posterior eyes in a slightly procurved line, equal; the median separated by the diameter and from the lateral by about one and one-half times the diameter. Anterior eyes in a straight line, median smaller than the lateral, separated by the radius and from the lateral by the diameter. Clypeus a little wider than median ocular area. Sternum dusky orange darker at the margin, as broad as long, produced into a point between the hind coxae which are separated by a little less than the diameter. Endites dusky orange. A tooth on the face of chelicera. Legs and palpi dusky orange. Abdomen gray.

Femur of palpus long, stout, curved, widened distally. Patella short, arched above. Ratio of length of femur to that of patella as 30 to 9. Tibia (figures 84, 86) strongly widened, the distal half black; the dorsal margin truncate with a deep notch rounded at the bottom on the dorso-mesal side. The paracymbium rather long with the end rolled over and emarginate. The embolic division (figure 85) is very similar to that of *probatus* but the anterior end of the scaphium bears a sharp curved tooth directed mesally. The teeth and scales on the posterior tooth are much coarser than in that species.

*Female*. Length, 4.2 mm. Similar to the male in form and color. The epigynum strongly protuberant, the lateral lobes are very large and convex, oval and are separated by a narrow T-shaped median lobe.

Type locality: Washington State.

Oregon: 1 ♂ 1 ♀ (Marx).

This species has also been recorded by Emerton from British Columbia: Laggan; Washington: Olympia. Banks recorded it from Albuquerque, N. M. Some of these records may refer to other species.

### **Catabrithorax pertinens** Cambridge

*Erigone pertinens* Cambridge. Zool. Soc. London Proc. 1875, p. 399, pl. 44, fig. 6
*Tmeticus pertinens* Emerton. Conn. Acad. Sci. Trans. 6:54, pl. 16, fig. 2. 1882
*Oedothorax pertinens* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 312

In the Museum of Comparative Zoology there are only two specimens of this species, ♂ and ♀. These are doubtless Cambridge's types.

*Male.* Length, 2.8 mm. Cephalothorax brown, rather broad, evenly rounded on the sides; viewed from the side, gradually ascending posteriorly, rounded over the head, highest behind the eyes. A median row of stiff bristles over top of head.

Posterior eyes in a straight line, the median separated by the diameter and a little farther from the lateral. Anterior median eyes much smaller than the lateral, close together but well separated from the lateral. Sternum grayish brown. Hind coxae separated by a little less than the diameter. Chelicera with a strong tooth on face and a few granulations on the side. Legs and palpi brownish-yellow. abdomen dark gray.

Patella of palpus short. Tibia (figure 87) short and broad; on the dorsal margin there are two apophyses, the dorsal one is acute and bears a small sharp tooth on the dorsal face, the lateral one is broadly triangular; between the two there is a deep rounded notch. The cymbium has a distinct enlargement at the base on the dorsal side. The paracymbium is very broad and thick with a small rounded notch. The posterior tooth of the embolic division consists of a broad pointed process the edge of which is armed with minute scale-like plates. This tooth (figure 94 *a*) stands erect, free from the rest of the bulb. The middle part of the embolic division has the outer edge turned up at a right angle to form a broadly triangular plate; this plate is separated from the ventral part by a deep rounded notch. The terminal part is rather squarish, bearing an erect tooth on the lateral corner and two processes on the apical corner, one above the other; the upper one is short and curved downward and the under one is more acute. No specimens are available for boiling and it is therefore impossible to determine the homology of these parts. The median apophysis appears as a rounded tooth laterad of and below the terminal part of the embolic division.

*Female.* Length, 3 mm. Similar to male in coloration but larger. The epigynum (figure 95) consists of three lobes, the middle one nearly square.

Described and figured from the types.

Type locality: Peaks island, Portland, Me.

## **Catabrithorax plumosus** Emerton

*Tmeticus plumosus* Emerton. Conn. Acad. Sci. Trans. 6:53, pl. 15, fig. 3, 1882
*Tmeticus obscurus* Banks. Phila. Acad. Nat. Sci. Proc. 1892, p. 38, pl. 4, fig. 14
*Tmeticus humilis* Banks. Phila. Acad. Nat. Sci. Proc. 1892, p. 39, pl. 4, fig. 18
*Gongylidium plumosus* Simon. Ar. Fr. 5:500, 1884
*Oedothorax plumosus* Crosby. Phila. Acad. Nat. Sci. Proc. 1905, p. 312
*Tmeticus plumosus* Banks. Phila. Acad. Nat. Sci. Proc. 1916, p. 74
*Gongylidium plumosus* Emerton. Royal Can. Inst. Trans. 12:316, 1919

*Male*. Length, 1.6 mm. Cephalothorax brown, darker near the margin with darker radiating lines; viewed from above rather broad, evenly rounded on the sides, convergent toward the front, rounded in front; viewed from the side, rounded to the cervical groove where there is a distinct depression and then rounded to the posterior eyes. Clypeus straight and vertical.

Posterior eyes in a slightly procurved line, equal, and equidistant, separated by the radius. Anterior eyes in a slightly procurved line, the median scarcely smaller than the lateral, equidistant, separated by a little less than the radius. Clypeus two-thirds as wide as the median ocular area. No tooth on the face of the chelicera. Sternum very dark brown, narrowly margined with black. Almost as wide as long, rounded on the sides produced as a truncated point between the hind coxae which are separated by a little less than the diameter. Labium dark. Endites dusky orange. Legs and palpi orange-yellow. Distal margin of coxae below narrowly banded with black. Abdomen dark gray, almost black.

Femur of palpus (figure 97) somewhat widened distally, gently curved inward. Patella rather short, gently arched above. Ratio of length of femur to that of patella as 16 to 6. Tibia (figure 101) short, widened distally, produced dorsally into a large rounded lobe with a rounded notch on each side; on the mesal side there is a broadly rounded tooth and on the lateral side a broader lobe. Paracymbium rolled over and the broad free margin has a terminal hooked tooth separated from a triangular tooth by a rounded emargination. The embolic division (figures 98, 99) complicated and of irregular form. The anterior tooth long, thin, flattened, with the sides parallel and ending in two points, the posterior shorter, the anterior longer, curved, acute. Near the base of the anterior tooth there is on the mesal side of the scaphium, a large, thin, up-curved acute tooth. On the lateral side of the scaphium there is a broad, thin, flat, longitudinal tooth with its apical edge finely fluted and irregular. The posterior tooth erect, curved forward, elongate, slender at base, thicker towards tip, acute, clothed with many short stiff hairs. Mesally from the base

of the posterior tooth there is a short, blunt, rounded, longitudinal tooth which is continuous with the mesal ridge of the scaphium. Opposite the posterior tooth the mesal margin of the scaphium is produced into a bluntly rounded tooth. This seems to represent the mesal tooth of Erigone.

*Female.* Length, 1.8 mm. Similar to the male in form and color. The epigynum (figure 100) strongly convex, straight behind. The middle lobe is a wedge-shaped plate pointed in front, and extended forward in a narrow slit nearly to the front margin.

Type localities: Montreal, Canada; Mount Washington, N. H.; Beverly, Mass.

New York: Mount McIntyre (summit) Essex county, July 1, 1923, 1 ♂ ; Ithaca, July 17, 1920, 1 ♂ ; Mar. 1910, 1 ♂ , Mar. 17, 1912, 1 ♂ ; Kingston, Mar. 12, 1919, 5 ♂ ; Constableville, Aug. 19, 1927, 1 ♂ (P. Needham).

Massachusetts: Winthrop beach, Nov. 12, 1922, 3 ♂ 1 ♀ ; Cambridge, Nov. 17, 1922, 1 ♂ on fence; Duxbury, June 4, 1921, ♂ (Bryant).

Connecticut: Mantic, May 15, 1912, ♂ (Emerton).

New Hampshire: Hollis, Aug., 1 ♂ (Fox), Aug. 4, 1911, ♂ ♀ (Bryant). Franconia, ♂ (Banks); Mount Washington, Sept. 1907, ♂ (Bryant)

Illinois: Salts, Aug. 26, 1926, 1 ♂ (Smith).

This species has also been recorded by Emerton from Quebec: Lake Megantic.

### **Catabrithorax probatus** Cambridge

*Erigone probata* Cambridge, Zool. Soc. London, Proc. 1874, p. 431, pl. 55, fig. 2
Not *Tmeticus probatus* Emerton, Conn. Acad. Sci. Trans. 6:52, pl. 15, fig. 1, 1882

We have not had specimens of *probatus* Cambridge but through the kindness of Dr A. Randall Jackson of Chester, England the types have been examined and compared with several closely related species. *C. probatus* is most nearly related to *C. ksenius* new species, from British Columbia from which it differs in the structure of the tibia of the palpus. In *probatus* the dorsal margin of the tibia is developed into a broad plate which has the lateral corner pointed and the mesal margin broadly rounded (figure 89). Mesad of the dorsal process there is a semicircular projection quite distinct from the simple angulate process of *ksenius*.

The following description is taken from that of Cambridge:

*Male.* Length, 3 mm. The cephalothorax is of the ordinary general form; but the occipital region of the caput is gibbous, and the normal grooves and indentations are fairly marked; it is of a darkish

yellow-brown color, the surface appearing to be very thickly but minutely punctuose; and there is a single central longitudinal row of nearly erect bristly hairs from the eyes to the thoracic junction. The height of the clypeus exceeds half that of the facial space.

The eyes are of moderate size, and seated on slight black tubercles; they are in two transverse curved rows, the foremost row being the shortest and straightest; those of the hind central pair are about an eye's diameter distant from each other, but nearer together than each is to the hind lateral on its side; those of the fore central pair are smallest of the eight, and are separated from each other by an interval of about half an eye's diameter, each being separated from the hind central nearest to it by the diameter of the latter, and from the fore lateral on its side by the latter's diameter; the laterals are seated obliquely on a strong tubercle, and are contiguous to each other.

The legs are rather long and tolerably strong, their relative length being 4, 1, 2, 3; they are of a brightish yellow color, and furnished with numerous hairs and fine bristles, some of the former being erect.

The palpi are short; the humeral and cubital joints rather slender; the radial is strong, a little longer than the cubital, and spreads out on all sides, its fore half being black and somewhat irregularly but boldly notched or emarginate; the color of the hinder part is orange red-brown, that of the cubital and humeral joints yellow, and the digital, which is oval, yellow-brown; the palpal organs are well developed and rather complex, with spines and corneous processes, one of the latter beneath their fore extremity being furnished with a row of fine comblike teeth. (See figure 90)

The falces are long, strong, and prominent near their base in front; near their inner extremity in front is a single strong sharp tooth; and along their inner edge, beneath the fang, are some other smaller teeth; their color is similar to that of the cephalothorax.

The maxillae are long and strong, slightly curved, and inclined to the labium, which is short and of a somewhat semicircular form; the color of these parts is similar to that of the legs.

The sternum is heart-shaped, of a dark yellow-brown color, and furnished with a few longish erect bristly hairs.

The abdomen is oval, not very convex above, but projecting considerably over the base of the cephalothorax; it is of a dull blackish brown color, clothed thinly with hairs.

The adult female is larger than the male; the abdomen is more convex above, as well as much larger; the falces want the strong sharp tooth in front near their extremity; but in other respects there is but little difference.

The form of the genital aperture is peculiar, and the process connected with it is large and prominent.

Two adults of each sex were contained in a small collection of Spiders kindly collected for me in Oregon Territory in 1872 by Lord Walsingham.

## **Catabrithorax utus** Chamberlin

*Hilaira uta* Chamberlin. Ann. Ent. Soc. Am. 12:253, pl. 18, figs. 8 & 9. 1919
*Montilaira uta* Chamberlin. N. Y. Ent. Soc. Jour. 29:40. 1921

*Male.* Length, 2.8 mm. Cephalothorax grayish-brown. Head gently raised behind the eyes into a low dome-shaped elevation, armed through the middle with a single row of stiff hairs directed forward. Posterior eyes in a straight line, the median separated by the diameter, and $1\frac{1}{2}$ times the diameter from the lateral. Anterior eyes in a very slightly recurved line, not much different in size, median separated by the radius, from the lateral by the diameter. Chelicerae armed on face with a large sharp tooth directed obliquely downward. Sternum gray brown; hind coxae less than their diameter apart. Endites yellow. Legs and palpi brownish yellow. Abdomen light gray.

Patella of tarsus slender, not quite so long as tibia. Tibia (figure 88) has dorsally on the inner side of the margin, a rounded notch with a thickened margin. Laterally from this notch the margin is evenly rounded without an apophysis. Paracymbium short and broad with a sharp hook. The subtegulum and tegulum strongly chitinized. The embolic division (figure 96) is similar to that of *C. ksenius* but as no specimen is available for boiling no careful comparison is possible.

Described from the type and figured from a specimen collected at Clear lake, Millard county, Utah. (Chamberlin).

## EXPLANATION OF PLATES

### Plate 1

Figure 1 *Erigone aletris.* Right palpus, lateral view

Figure 2 *Erigone aletris.* Embolic division, anterio-mesal view

Figure 3 *Erigone aletris.* Embolic division, mesal view. *a*, posterior tooth; *b*, median tooth; *c*, anterior tooth; *d*, mesal tooth; *s*, scaphium

Figure 4 *Erigone aletris.* Epigynum

Figure 5 *Erigone alsaida.* Right palpus, lateral view

Figure 6 *Erigone alsaida.* Tip of palpus showing embolic division; *e*, median apophysis

Figure 7 *Erigone arctica.* Right palpus, lateral view

Figure 8 *Erigone arctica.* Tip of palpus showing embolic division

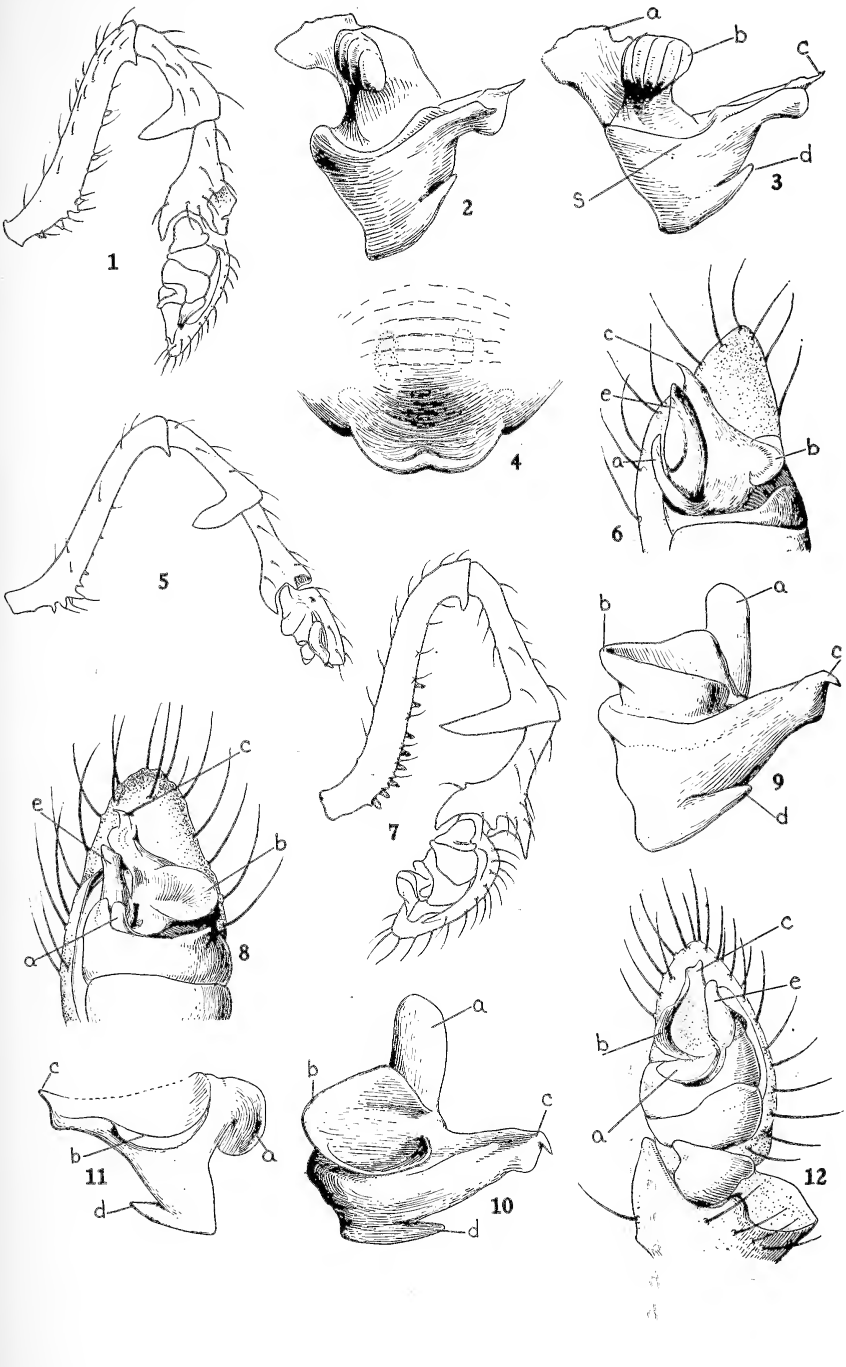
Figure 9 *Erigone arctica.* Embolic division, anterio-mesal view

Figure 10 *Erigone arctica.* Embolic division, ventro-mesal view

Figure 11 *Erigone arctophylacis.* Embolic division of left palpus, mesal view

Figure 12 *Erigone arctophylacis.* Left palpus, ventral view

Plate I



## Plate 2

Figure 13 *Erigone arctophylacis.* Left palpus, lateral view

Figure 14 *Erigone atra.* Right palpus, lateral view

Figure 15 *Erigone atra.* Right palpus. Tibia and tarsus, ventro-lateral view

Figure 16 *Erigone atra.* Embolic division, anterio-mesal view

Figure 17 *Erigone atra.* Embolic division, mesal view

Figure 18 *Erigone autumnalis.* Right palpus, lateral view

Figure 19 *Erigone autumnalis.* Right palpus. Tibia and tarsus, ventro-lateral view

Figure 20 *Erigone autumnalis.* Embolic division, mesal view

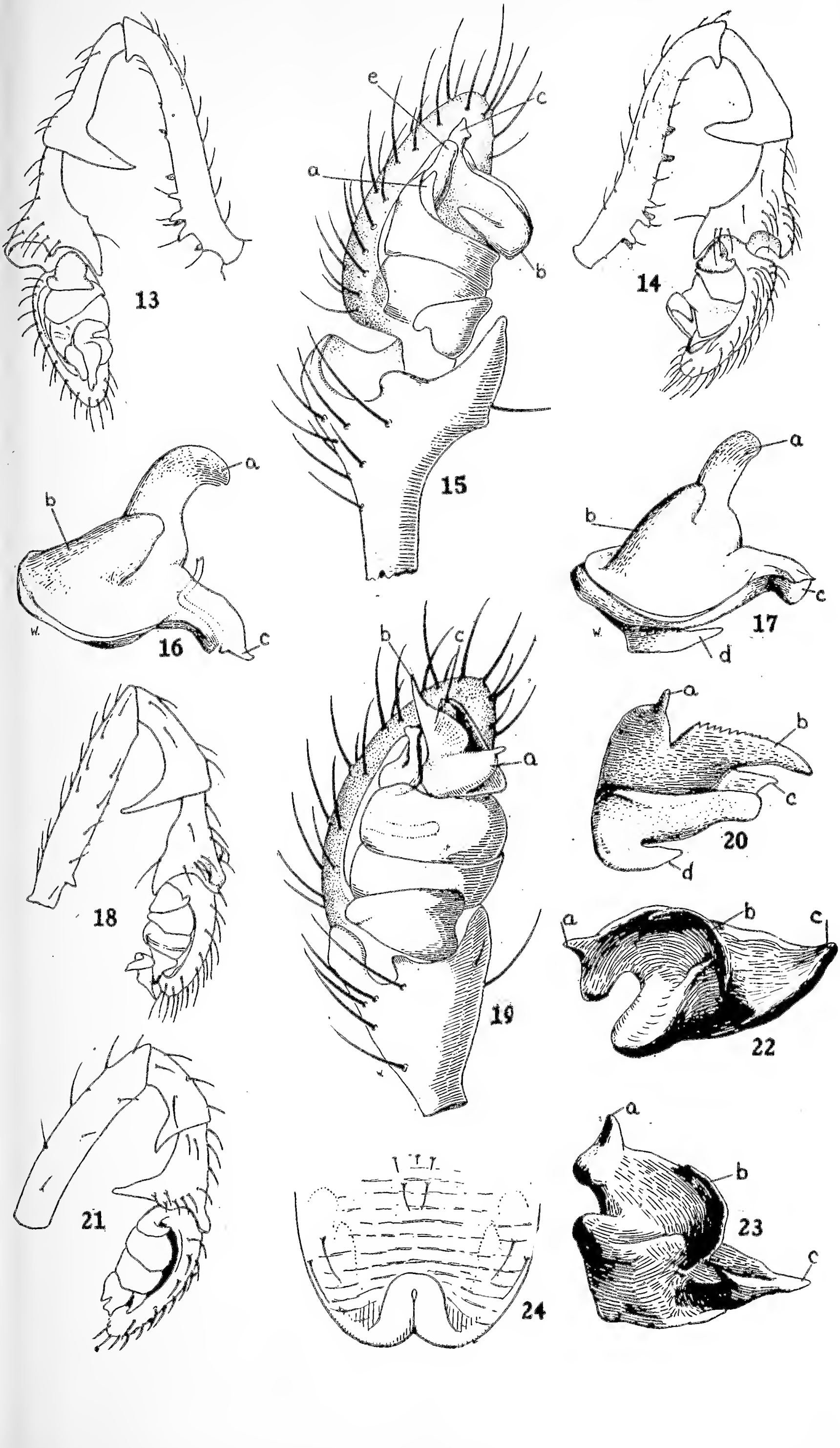
Figure 21 *Erigone barrowsi.* Right palpus, lateral view

Figure 22 *Erigone barrowsi.* Embolic division, ventral view

Figure 23 *Erigone barrowsi.* Embolic division, mesal view

Figure 24 *Erigone barrowsi.* Epigynum

Plate 2



## Plate 3

Figure 25 *Erigone barrowsi.* Right palpus. Tip of tarsus, ventro-lateral view

Figure 26 *Erigone blaesa.* Right palpus, lateral view

Figure 27 *Erigone blaesa.* Right tibia, dorso-lateral view

Figure 28 *Erigone blaesa.* Right palpus. Tip of palpal organ

Figure 29 *Erigone blaesa.* Embolic division, mesal view

Figure 30 *Erigone blaesa.* Embolic division, anterio-mesal view

Figure 31 *Erigone blaesa.* Epigynum

Figure 32 *Erigone brevidentata.* Right palpus, lateral view

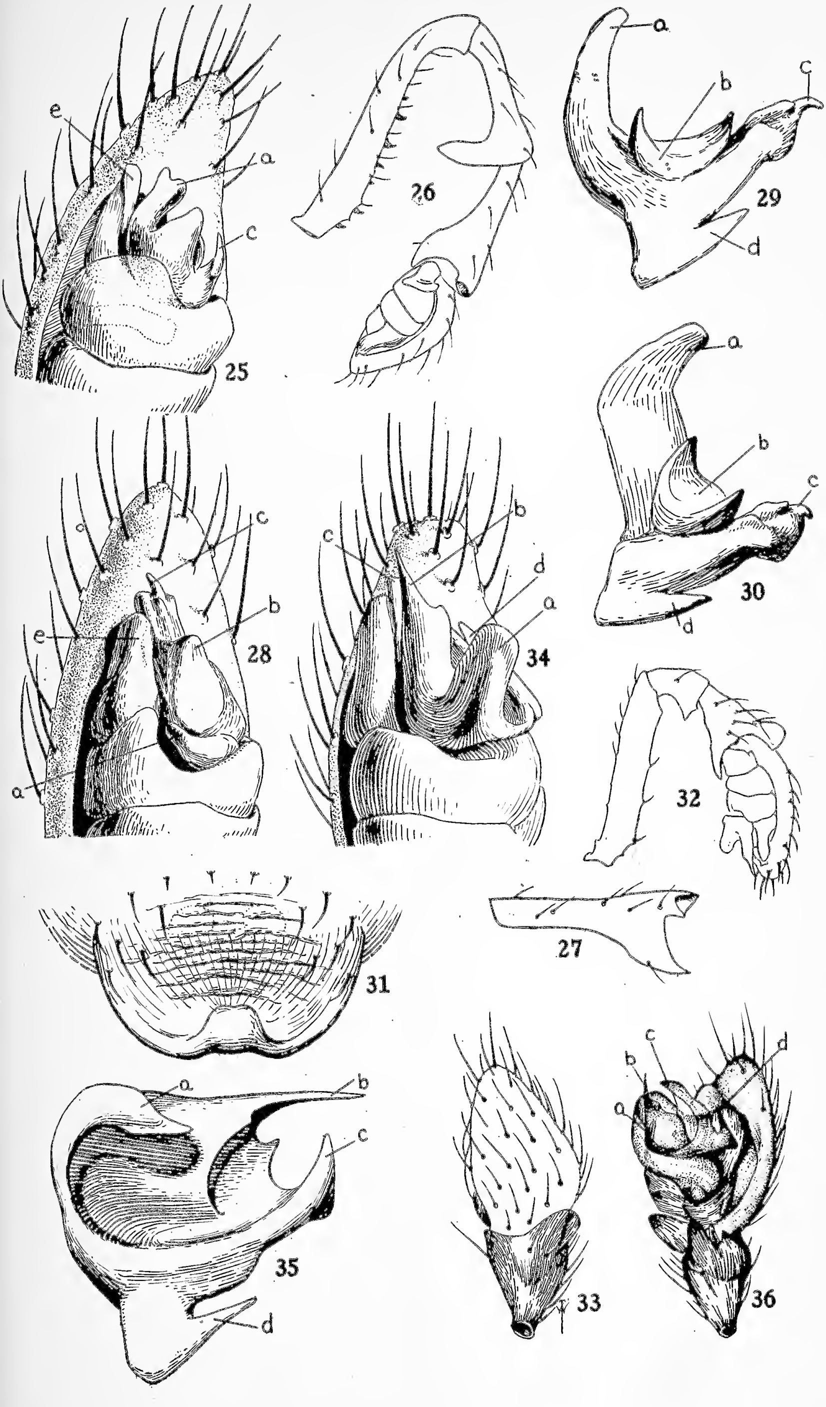
Figure 33 *Erigone brevidentata.* Right palpus. Tibia and tarsus, dorso-mesal view

Figure 34 *Erigone brevidentata.* Right palpus. Tip of palpal organ, ventral view

Figure 35 *Erigone brevidentata.* Embolic division, mesal view

Figure 36 *Erigone brevidentata.* Right palpus. Tibia and tarsus, ventro-mesal view

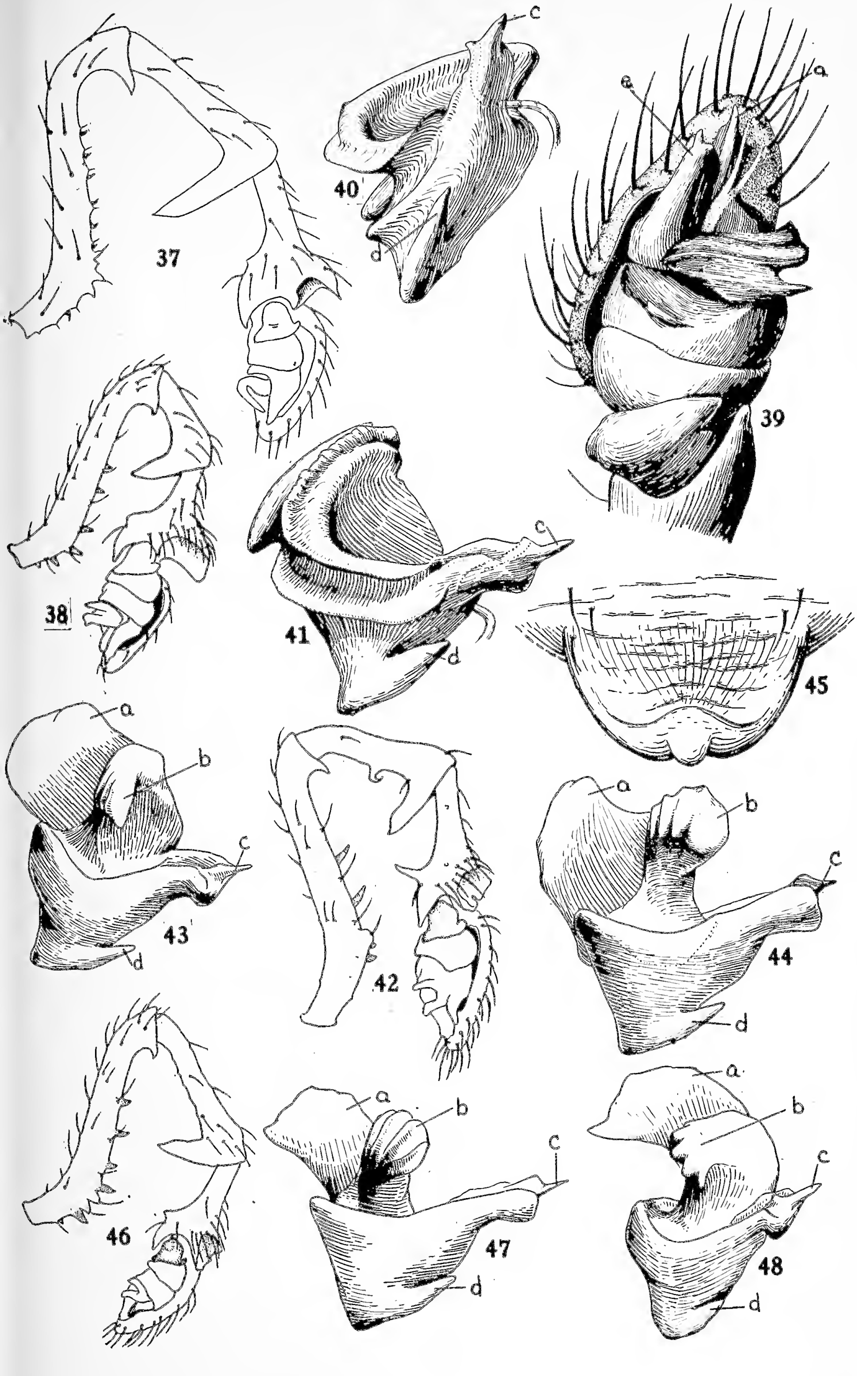
Plate 3



## Plate 4

Figure 37 *Erigone siberica.* Right palpus, lateral view
Figure 38 *Erigone dentigera.* Right palpus, lateral view
Figure 39 *Erigone dentigera.* Right palpus, ventro-lateral view
Figure 40 *Erigone dentigera.* Embolic division, anterior view
Figure 41 *Erigone dentigera.* Embolic division, anterio-mesal view
Figure 42 *Erigone dentosa.* Right palpus, lateral view
Figure 43 *Erigone dentosa.* Embolic division, anterio-mesal view
Figure 44 *Erigone dentosa.* Embolic division, mesal view
Figure 45 *Erigone dentosa.* Epigynum
Figure 46 *Erigone ephala.* Right palpus, lateral view
Figure 47 *Erigone ephala.* Embolic division, mesal view
Figure 48 *Erigone ephala.* Embolic division, anterior view

Plate 4



## Plate 5

Figure 49 *Erigone hypenema.* Right palpus, lateral view

Figure 50 *Erigone hypenema.* Right palpus. Tip of palpal organ, ventral view

Figure 51 *Erigone hypenema.* Embolic division, mesal view

Figure 52 *Erigone hypenema.* Embolic division, anterio-mesal view

Figure 53 *Erigone labra.* Right palpus, lateral view

Figure 54 *Erigone labra.* Embolic division, anterio-mesal view

Figure 55 *Erigone labra.* Embolic division, mesal view

Figure 56 *Erigone metlakatla.* Right palpus, lateral view

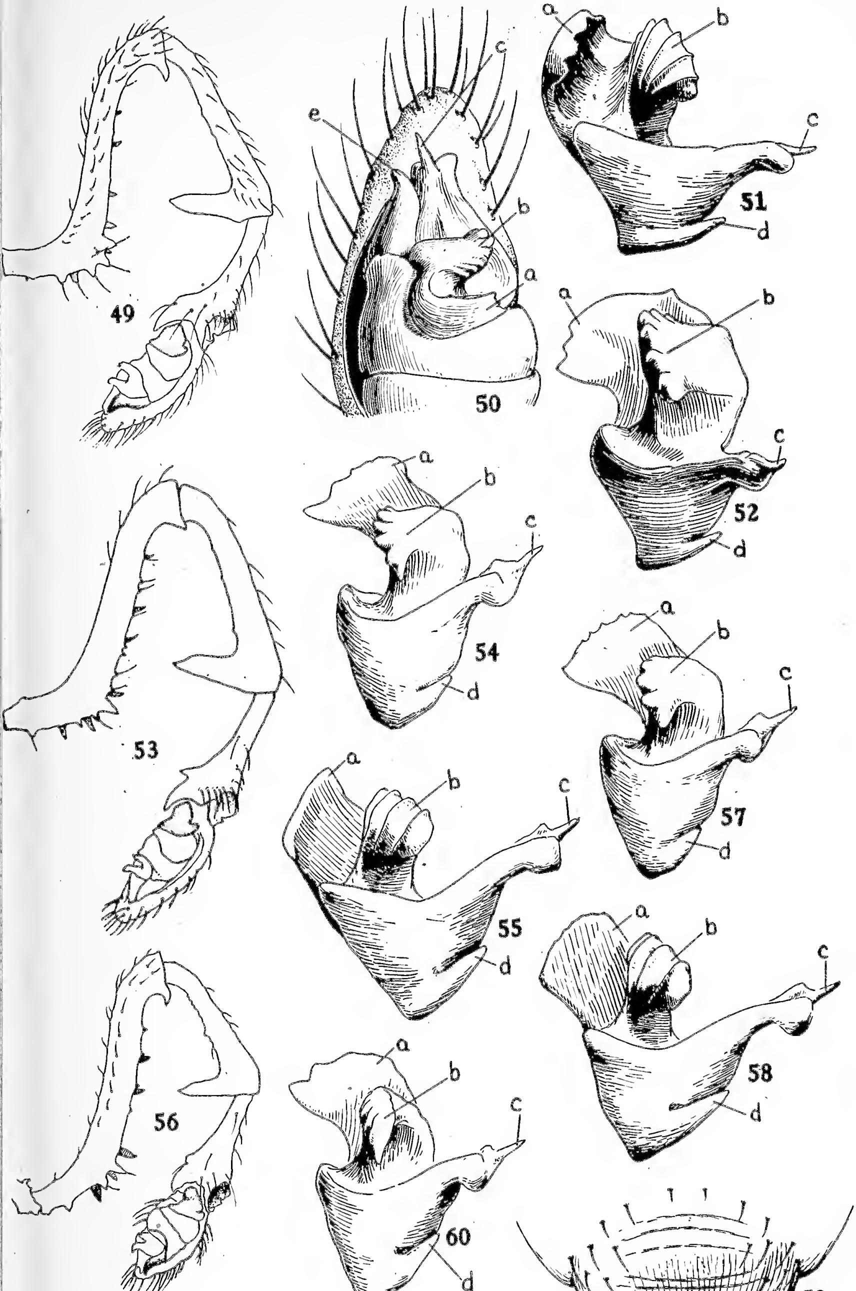
Figure 57 *Erigone metlakatla.* Embolic division, anterio-mesal view

Figure 58 *Erigone metlakatla.* Embolic division, mesal view

Figure 59 *Erigone hypenema.* Epigynum

Figure 60 *Erigone olympias.* Embolic division, anterior view

Plate 5



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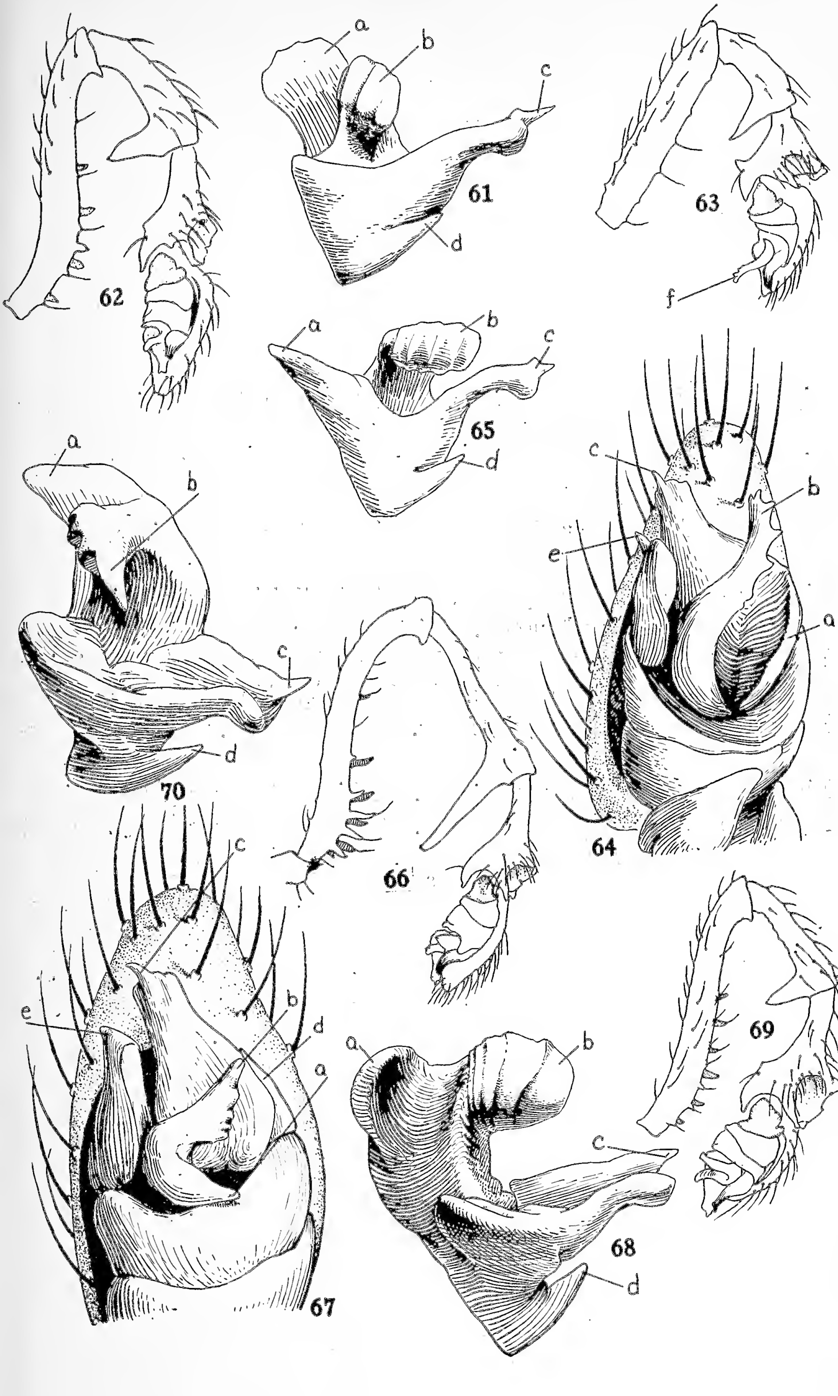
## Plate 6

Figure 61 *Erigone olympias.* Embolic division, mesal view
Figure 62 *Erigone olympias.* Right palpus, lateral view
Figure 63 *Erigone ourania.* Right palpus, lateral view
Figure 64 *Erigone ourania.* Right palpus, ventral view
Figure 65 *Erigone ourania.* Embolic division, mesal view
Figure 66 *Erigone psychrophila.* Right palpus, lateral view
Figure 67 *Erigone psychrophila.* Right palpus. Tip of palpal organ
Figure 68 *Erigone psychrophila.* Embolic division, mesal view
Figure 69 *Erigone zographica.* Right palpus, lateral view
Figure 70 *Erigone psychrophila.* Embolic division, anterio-mesal view

Plate 6



## Plate 7

Figure 71 *Erigone tenuipalpus.* Right palpus, lateral view; tarsus turned to give ventral view

Figure 72 *Erigone tenuipalpus.* Right palpus. Tibia and tarsus, dorsal view

Figure 73 *Erigone tenuipalpus.* Tibia and paracymbium, dorso-lateral view

Figure 74 *Erigone tenuipalpus.* Embolic division, mesal view

Figure 75 *Erigone whymperi.* Right palpus, lateral view

Figure 76 *Erigone zographica.* Embolic division, anterio-mesal view

Figure 77 *Erigone zographica.* Embolic division, mesal view

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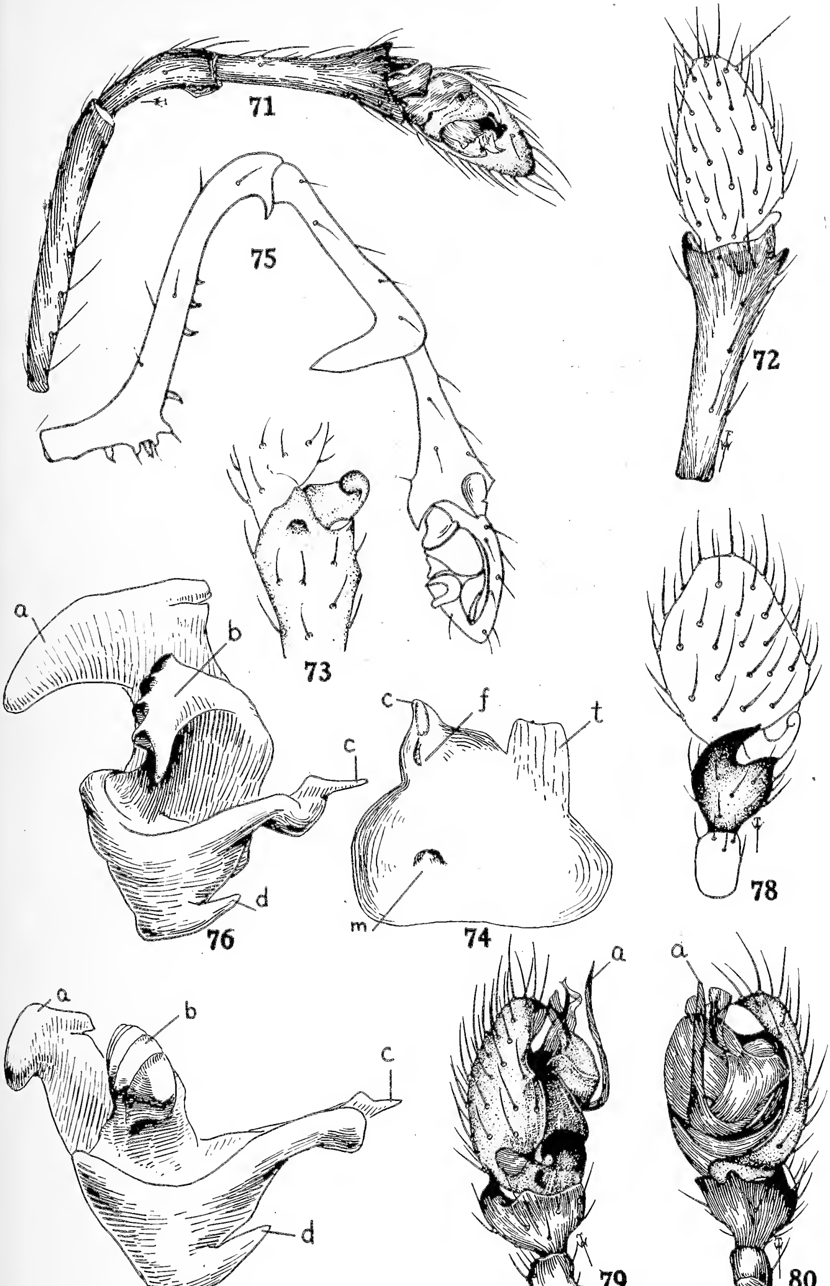

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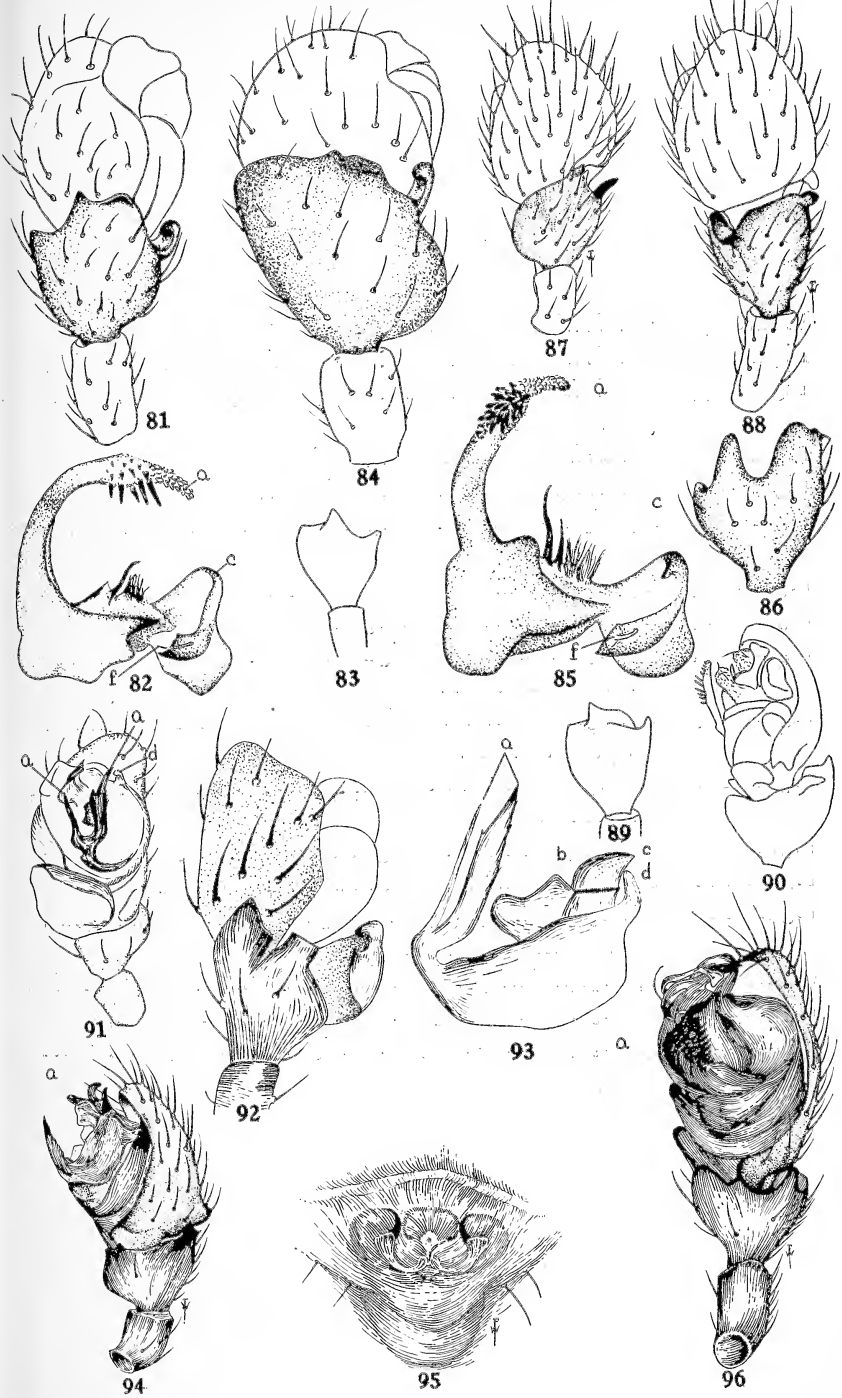

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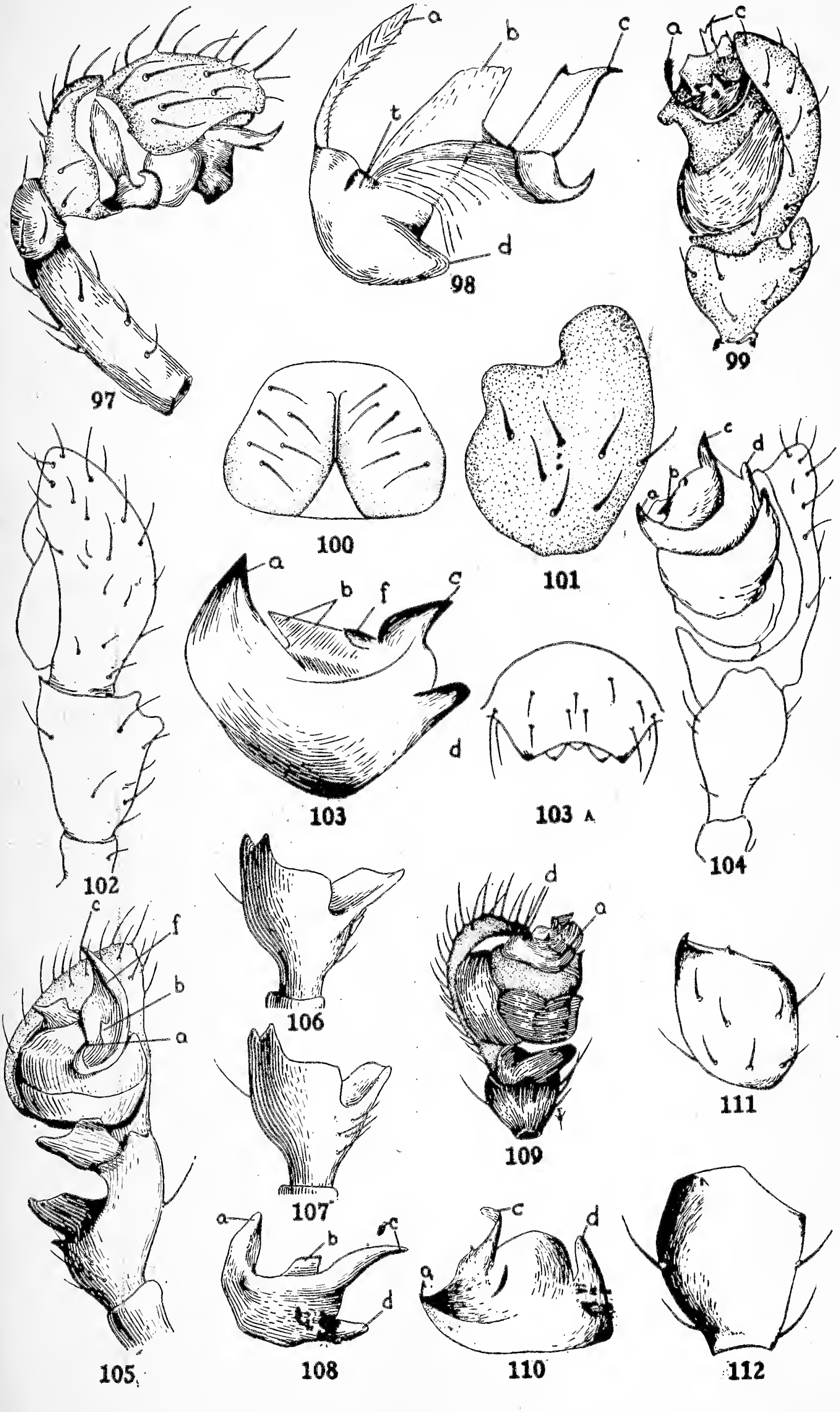
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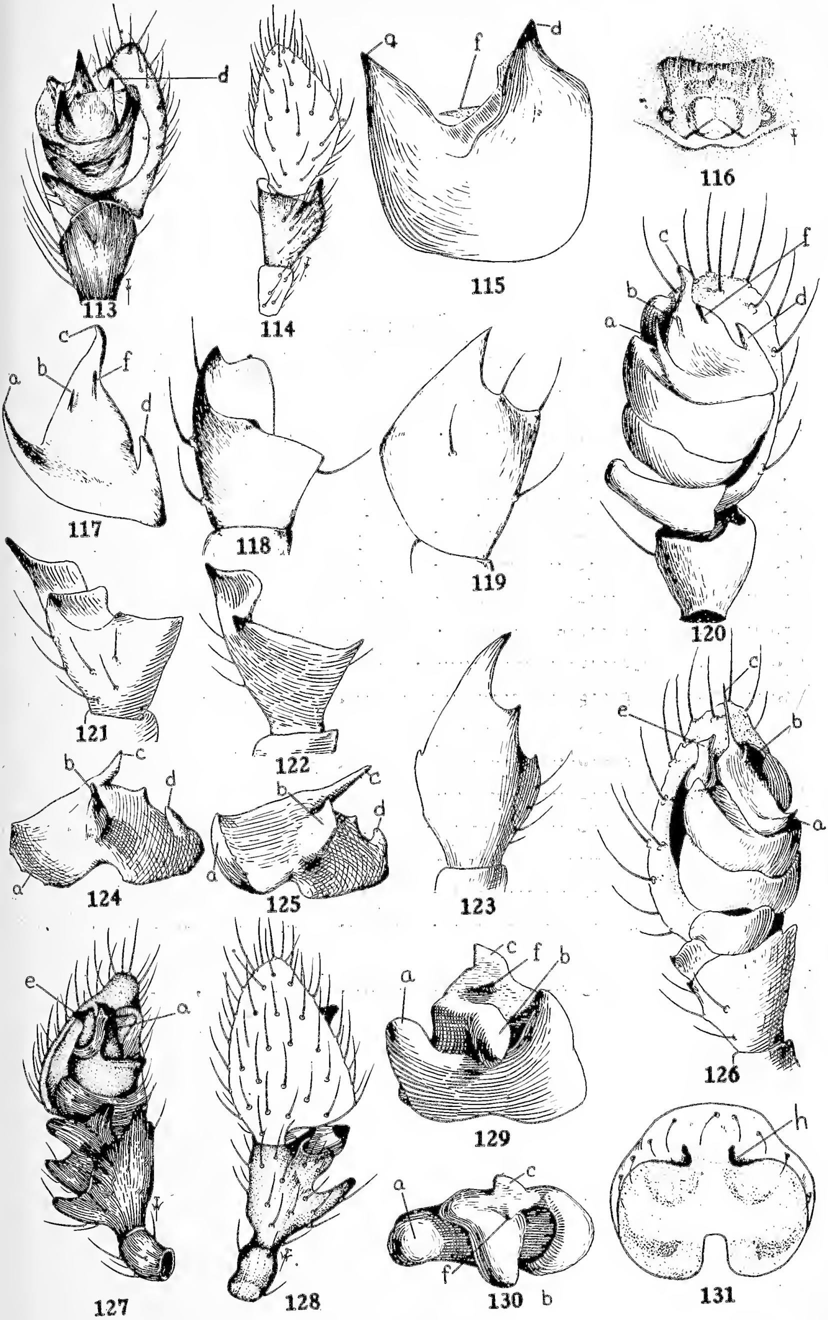
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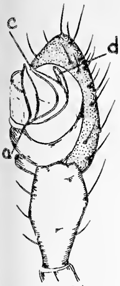


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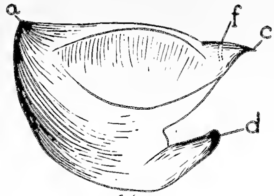


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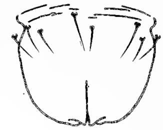

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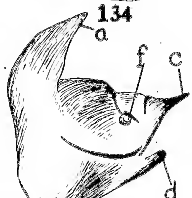


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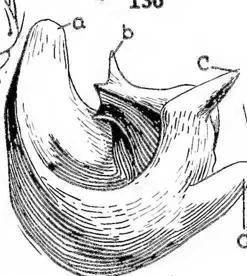


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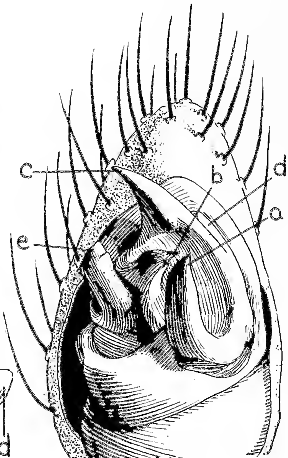


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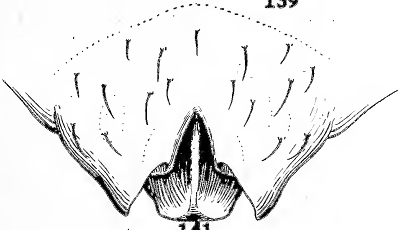

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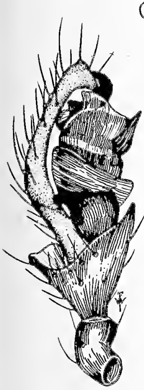

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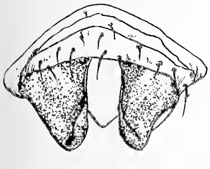

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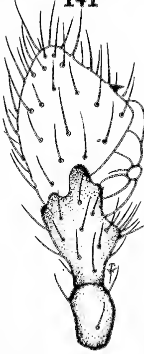

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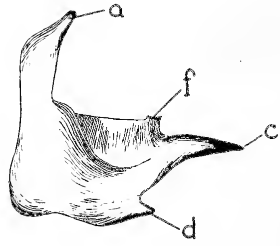


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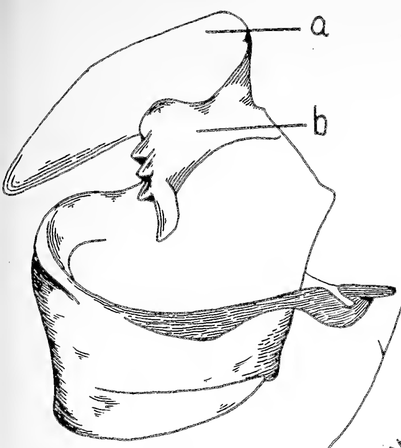


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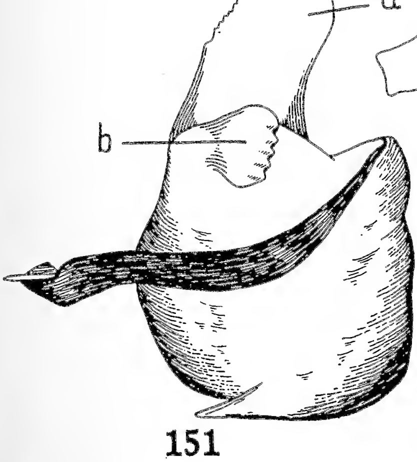


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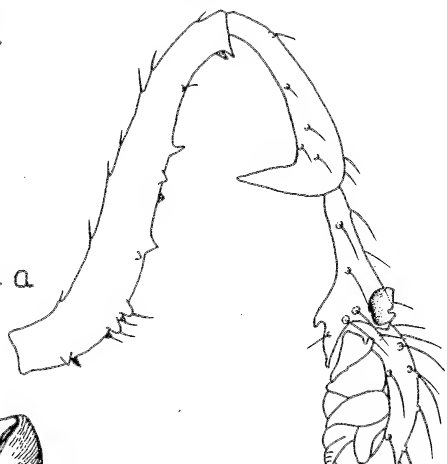

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# REVISION OF THE SPIDER GENUS TETRAGNATHA

BY

RALPH M. SEELEY

CONTENTS



## INTRODUCTION

This study is based principally on the specimens in the large collection of Cornell University which was unreservedly put at my disposal by Professor C. R. Crosby. Dr S. C. Bishop kindly lent me the material in the collection of the New York State Museum and Dr Frank E. Lutz lent that of the American Museum of Natural History in New York City. Some material taken from frogs' stomachs was received from the Biological Survey of Washington, D. C., for identification. J. H. Emerton loaned me a male of *T. vermiformis*, a male and female of *T. pallescens* and some immature specimens of *T. pinicola* Emerton. I take this opportunity of extending my thanks to all these men for their favors.

I owe appreciation especially to Professor C. R. Crosby, who not only suggested the need of revising this genus and gave me unreserved use of the material in the Cornell University collection, but also took a wholehearted interest in the progress of the investigation, made timely and helpful suggestions which greatly facilitated the work, and finally kindly criticized the manuscript for this paper. Figures 22–24 were drawn by Walter J. Schoonmaker.

## **Tetragnatha** Latreille

Type: *Aranea extensa* Linnaeus
*Tetragnatha* Latreille. Nouv. Dict. d'Hist. nat. 24:135. 1804
*Tetragnatha* Walckenaer. Tabl. Aran., p. 68. 1805
*Tetragnatha* Latreille. Gen. Crust. et Insect. 1:101, pl. 4, fig. 4. 1806
*Tetragnatha* Latreille. Consid. Général. des Animaux, p. 125 and 424. 1810

*Eugnatha* Andouin and Savigny. Descrip. d'Égypt. 22:118, pl. 2, fig. 2-4. 1827

*Deinagnatha* White. Travels in New Zealand. 2:271. 1843

*Deinagnatha* White. Ann. & Mag. Nat. Hist. 18:180. 1846

*Eugnatha* Thorell. K. Svenska Vet. Akad. Fördhl. 15:194. 1858

*Eugnatha* Thorell. On European Spiders, p. 62. 1869

*Tetragnatha, Eugnatha, Eucta* Simon. Arach. France. 5:2, 1881

*Tetragnatha* and *Limoxera* Thorell. Mus. Civ. St. Nat. Genova (2) 8:223. 1889-90

*Tetragnatha* and *Eucta* Simon. Hist. Nat. Araign. (Ed. 2) 1:723 and 725. 1894

*Tetragnatha* and *Eucta* Comstock. Spider Book, p. 408 and 415. 1912

The name *Tetragnatha* was first proposed by Latreille in 1804. He gave a short diagnosis, but did not name the species to be included except to say " Les spiraliformes de Walckenaer." In 1805 Walckenaer used the name *Tetragnatha* and placed in it four species of which only one, *T. extensa*, is valid, the others not being described. Latreille in 1806 gave a diagnosis of the genus *Tetragnatha*, placed in it the one species *T. extensa*, and in 1810 he definitely indicated *extensa* as the type.

*Eugnatha* is clearly a synonym of *Tetragnatha*. This name was used by Savigny when he drew up the plates of spiders for the work Description d'Égypt. Audouin, however, wrote the text which is entitled, " Explication sommaire des planches dont les dessins ont été fournis par M. J. C. Savigny pour l'histoire naturelle de l'ouvrage " (1827). In *Eugnatha* were placed *E. nitens*, *E. pelusia*, and *E. filiformis*. Audouin has this to say at the beginning of his work, " M. Savigny, dans les recherches détaillées qu'il a faites, a reconnu combien étoient naturels les genres établis par Mm. Walckenaer et Latreille; et il s'est empressé de les admettre, sans cependant en conserver toujours la circonscription: ainsi il a cru devoir créer souvent des genres aux dépens de ceux qui étoient déjà formés." And on page 118 he says, " M. Savigny a cru devoir substituer le nom d'Eugnatha à celui de Tetragnatha; mais il a conservé la circonscription de ce genre très naturel." It is thus a clear case of substitution of the name *Eugnatha* for *Tetragnatha* and the author had no intention of establishing a new genus. Thorell, however, later (1858) proposed that *Eugnatha* be kept for Walckenaer's *Uloborus filiformis* (=*Eugnatha filiformis* Savigny) and characterized it as having an extremely elongated threadlike abdomen which ends in a point and having the spinnerets far removed from the apex to near the middle of the venter (*Eucta* Simon). He repeated this point in 1869. By the rules of nomenclature, however, *Eugnatha* can not now be

used because it is a pure synonym of *Tetragnatha*. Simon (1881) recognized *Eugnatha* and placed in it two species, *E. striata* L. Koch and *E. filiformis* Savigny. Later, however, (1894) he united *Eugnatha* with *Tetragnatha*.

So far as the American forms are concerned, *Eucta* need not be recognized. This genus was established by Simon (1881) who placed three species in it. In 1894 he indicated *E. gallica* Simon as type. In 1881 he separated *Eucta* from *Eugnatha* (which he recognized at that time) on the following characters: Posterior row of eyes much more strongly recurved, in a half circle; cephalothorax very straight and very long: abdomen prolonged into a tail beyond the spinnerets; legs 1, 4, 2, 3, first pair much longer and more robust than the following. *Eugnatha* he characterized as having the two rows of eyes almost equally, and but little, bent: cephalothorax and abdomen of the same form as in *Tetragnatha;* legs, 1, 2, 4, 3, first and second pairs almost equal in length and thickness. From my examination of specimens of both *caudata* and other species of *Tetragnatha* I believe *caudata* should go into *Tetragnatha*. I do not find the posterior row of eyes in *caudata* so much more recurved than in *pallescens*. The cephalothorax and abdomen of *caudata* are certainly very straight and very long, but they are almost as much so in *pallescens* and *straminea*. These two characters are therefore of no practical value. In his "Histoire Naturelle des Araigneés" v. 1, p. 721, Simon further emphasizes the leg and " tail " characters in these words: " If the genus *Eugnatha* should be reunited to the genus *Tetragnatha*, the genus *Eucta* E. Sim. merits being maintained, for it is distinguished by two constant characters which give to its species a special appearance: its anterior legs, much longer and thicker than the others, and its cylindrical abdomen very long, prolonged, beyond the spinnerets, into a caudiform tubercle, subacute, analogous to that of *Ariamnes*." In *caudata* the first leg is slightly thicker than the second, but in *pallescens* this is also the case. The first leg of *caudata* is longer than the following, but so is it in all the other species of *Tetragnatha*. In specimens of *caudata* that I have measured, the fourth leg measured about 15.5 mm, the second about 14.5 mm, a difference of 1 mm. In *pallescens* the second and fourth legs are about equal in length, in *straminea* the second is about 1 mm longer than the fourth. Since the relative lengths vary in the same species, this character will hardly serve. The only character that might hold as a generic distinction is the " tail " of *caudata*. But this is open to question also. Comstock in The Spider Book, p. 415, says, " I have found by observing living individuals (of *caudata*) that the tail of

these spiders can be extended and contracted a considerable distance, so that the length of the abdomen may vary greatly from moment to moment." Simon does not mention *caudata* in either of the above works, but he places *vermiformis* Em. in *Eucta*. Petrunkevitch has done the same in his catalog. If *vermiformis* is placed in *Eucta*, then also *pallescens* and *straminea* must go along with it for *vermiformis* is obviously more closely related to these two species than to *caudata* which is usually placed in *Eucta*. I have therefore combined *Eucta* with *Tetragnatha*.

*Deinagnatha* White is a subgenus of *Tetragnatha*.

*Limoxera* was established by Thorell for several species from India and the Malay region. Simon (1894) makes of it a subgroup of *Tetragnatha*.

The genus *Tetragnatha* as thus understood may be characterized as follows. The body is long and narrow, several times longer than wide, and provided with very long, slender, spiny legs. When at rest the two front pairs of legs are extended forward and the rear legs backward parallel with body. The cephalothorax is oval, widest near the middle, flattened on top, with a prominent median furrow. The eyes are in two rows across the front of the head; these rows may be parallel, or they may converge or diverge at the sides, but the lateral eyes are never contiguous. Each eye is surrounded by a black ring. The mandibles are greatly developed, especially in males, and are provided with numerous teeth. In males, in addition to the two rows of teeth on the margins of the furrow, there is a strong, upward and forward projecting spur on the dorsal side of the mandible near the tip; this may be bifid at the tip or not. The endites are long and narrow, parallel, the tips expanded on the outer side. The abdomen is at least twice as long as wide and usually somewhat swollen near the base in females. There is no epigynum, the genital opening being covered with a membranous flap. The spinnerets are terminal except in one species in which the abdomen usually projects about a fourth of its length beyond the spinnerets.

The bulb of the male palpus is similar in all of our species of this genus. The bulb of *T. elongata* (pl. 2, fig. 14) and *T. laboriosa* (pl. 3, fig. 30) are here described as examples. It is a comparatively simple organ. Arising at the tip of the tibia is the cymbium, which is a narrow chitinized flap extending the whole length of the bulb. Attached to the cymbium at the base is the paracymbium which is half as long as the cymbium. Both cymbium and paracymbium are densely covered with hair. The tegulum is attached to the cymbium by a haematodocha which shows in the figure between the cymbium

and paracymbium. The tegulum is a ringlike, chitinized part, incomplete on the side covered by the cymbium, but on the other side globose in appearance. The embolus, after arising from the interior of the tegulum at one side, makes a turn around the inner distal rim of the tegulum then projects outward, parallel to the axis of the palpus. The proximal end of the embolus is bulblike in form and embedded in the membrane within the tegulum. The ejaculatory duct traverses the entire length of the embolus, opening at its very tip. The conductor arises from the center of the tegulum and extends through the spiral of the embolus. It is a broad, lightly chitinized sheet, spirally twisted around the embolus so as to inclose it apically. In *elongata* and *extensa* the conductor is conspicuously ridged and furrowed longitudinally, adding much to its strength, but in *laboriosa* this is not so evident. The tip of the conductor is folded over to form a kind of cap under which the tip of the embolus rests. In most of the species this cap is as shown for *T. elongata* (pl. 2, fig. 15), but in *T. laboriosa* it takes a somewhat different shape (pl. 3, fig. 31).

## Species of Tetragnatha Described by Walckenaer

Walckenaer's names given in Histoire Naturelle des Insectes Apteres v. 2, p. 203–23, 1837, have caused much confusion as some of them are descriptions drawn from drawings that were never published. His North American species are as follows: *extensa*, *elongata*, *fulva*, *fimbriata*, *culicivora*, *sanctitata*, *aurata*, *versicolor*, *viridis*, *lutea*, *flava*, *violacea*, *trapezoides*, *casula*, *argyra*, *zorilla*, *lacerta*. Of these species only the first two were described from specimens. The remainder were evidently described wholly from the drawings in the Bosc and Abbot manuscripts and are therefore invalid. McCook says (Acad. Nat. Sci. Phila. 1888, p. 74–79) he devoted " an hour or two to the study of the figures," and that he " was able at once to recognize a number of species which have long and familiarly been known under the names published by Hentz." In American Spiders v. 3, p. 260, footnote, he considers Walckenaer's *T. fulva*, *T. fimbriata*, and *T. violacea* as identical with *T. elongata*, and on p. 266, he considers *T. lacerta* Walckenaer to be the same as *T. caudata* Emerton. Petrunkevitch in his catalog follows McCook so far as he goes, but where McCook is silent, Petrunkevitch has listed Walckenaer's names as valid species.

## Key to the Species of Tetragnatha

*Males*

1 Lateral eyes of each side farther apart than the median................10
Lateral eyes not farther apart than the median..........................2
2 Lateral eyes of each side as far apart as the median....................3
Lateral eyes of each side closer together than the median...............5
3 Dorsal spur not bifid...........................*orizaba* Banks p. 130
Dorsal spur bifid.......................................................4
4 Tibia and patella of palpus both small and about equal in length; legs yellowish or white...........................*laboriosa* Hentz p. 123
Tibia at least twice as long as patella; legs green.........*pinea* n.n. p. 133
5 Dorsal spur on mandible not bifid but having a tooth below the apex......6
Dorsal spur distinctly bifid............................................7
6 None of the teeth abnormally enlarged.................*seneca* n. sp. p. 134
The two apical teeth of the upper margin greatly enlarged and slightly out of line of the other teeth...................*antillana* Simon p. 105
7 Mandibles shorter than the cephalothorax................................8
Mandibles at least as long as the cephalothorax.........................9
8 Fang evenly curved on both inner and outer surfaces *extensa* Linnaeus, p. 113
Fang evenly curved on the outer surface but undulating on the inner surface.......................................*banski* McCook p. 106
9 Mandibles longer than the cephalothorax; upper row with at least nine teeth.................................*elongata* Walckenaer p. 109
Mandibles as long as the cephalothorax; upper row with about seven teeth..................................*limnocharis* n. sp. p 129

10 Abdomen prolonged into a distinct " tail " beyond the spinnerets *caudata* Emerton p. 107
Spinnerets terminal or placed just under the tip of abdomen.............11
11 Tibia and patella of palpus both small and about equal in length; dorsal spur on mandibles not bifid..........................................12
Tibia twice as long as patella..........................................13
12 Lateral eyes on each side but little farther apart than the median; only one enlarged tooth.......................*orizaba* Banks p. 130
Lateral eyes very far apart; two very large teeth besides the dorsal spur *vermiformis* Emerton p. 138
13 Dorsal spur not bifid; no enlarged tooth in upper row.*pallescens* Banks p. 131
Dorsal spur bifid; a large tooth in the upper row..*straminea* Emerton p. 136

## Key to the Species of Tetragnatha

*Females*

1. Lateral eyes of each side farther apart than the median................9
Lateral eyes not farther apart than the median..........................2
2 Lateral eyes of each side about as far apart as the median..............3
Lateral eyes closer together than the median............................5
3 Distinctly greenish; legs with very long spines..........*pinea* n. n. p. 133
Silvery in appearance; legs with short spines...........................4
4 Mandibles with about 5 teeth on each margin of the furrow *orizaba* Banks p. 130

Mandibles with about six teeth on upper margin and 8 on lower *laboriosa* Hentz p. 123

5 Apical tooth of lower margin of the furrow of mandible very large and directed forward (pl. 1, fig. 3); mandibles longer than cephalothorax.................................*antillana* Simon p. 105

Apical tooth not conspicuously enlarged.................................6

6 Fang without a tooth at the base on the outer side but with a minute tooth on the inner side; mandibles scarcely half as long as the cephalothorax.................................*seneca* n. sp. p. 134

Fang with a tooth on the outer side at base; no tooth on inner side.......7

7 Abdomen light gray with small pearly white dots..*limnocharis* n. sp. p. 129

Abdomen with dark markings.................................8

8 Fang strongly sinuate; mandibles almost as long as the cephalothorax *elongata* Walck. p. 109

Fang evenly curved; mandibles little more than half as long as the cephalothorax.................................*extensa* Linn. p. 113

9 Abdomen prolonged into a distinct "tail" beyond the spinnerets *caudata* Emerton p. 107

Spinnerets apical or placed just below the tip of the abdomen...........10

10 Mandibles extending almost horizontally from the head; no tooth on base of fang; endites not hiding more than the tip of the folded fang.................................*pallescens* Camb. p. 131

Mandibles extending more vertically from the head; a small tooth at the base of fang on outer side; endites hiding more than the tip of the fang.................................*straminea* Emerton p. 136
*vermiformis* Em. p. 138

## **Tetragnatha antillana** Simon

Plate 1, figures 1–4

*Tetragnatha antillana* Simon. Proc. Zool. Soc. London, 1897, p. 868

*Tetragnatha antillana* Banks. U. S. Nat. Mus. Proc. 24:220. 1901

*Tetragnatha antillana* Cambridge. Biol. Centrali-Americana. Arachnida 2:433, pl. 41, fig. 5, 6. 1903

*Tetragnatha antillana* Banks. Acad. Nat. Sci. Phila. Proc. 1909, p.207

*Tetragnatha antillana* Petrunkevitch. Am. Mus. Nat. Hist. Bull. 29:389. 1911

*Tetragnatha antillana* Lutz. N. Y. Acad. Sci. Ann. 26:88. 1915

*Tetragnatha eremita* Chamberlin. Calif. Acad. Sci. Proc. 12:645, fig. 89, 90. 1924

*Male.* Total length (exclusive of chelicerae) 7.3 mm; cephalothorax 2.5 mm long, 1.3 mm wide; abdomen 5 mm long, 1 mm wide; chelicerae 3 mm; first leg, femur 6.5 mm, patella 1 mm, tibia 6.5 mm, metatarsus 7 mm, tarsus 1.7 mm; palpus, femur 2 mm, patella 0.6 mm, tibia 0.8 mm.

Cephalothorax, mandibles and legs dull yellowish, the sternum slightly darker; the cephalothorax somewhat dusky in the middle and along the edges. The posterior row of eyes is nearly straight,

the anterior row slightly recurved so that the lateral eyes of each side are closer together than the median eyes. The posterior eyes are equidistant, equal in size and the largest of all the eyes. The anterior lateral are the smallest and farther removed from the anterior median than the anterior median are apart. The latter are almost contiguous. The mandibles are longer than cephalothorax. The upper margin of the furrow has eight small teeth, the four nearest the base close together, the others far apart. In addition to these there are three greatly enlarged teeth situated above the margin near the apex of the mandible. One of these forms the dorsal spur; it projects straight forward and is not bifid, but it has a tooth below the apex. The lower margin has nine small teeth evenly spaced. The fang is very slightly sinuate.

The abdomen tapers from the unnotched base to the apex. It is dull silvery with grayish reticulations and a slight indication of a folium. Below it is darker.

*Female.* Total length (exclusive of chelicerae) 10 mm; cephalothorax 3.5 mm long, 2 mm wide; abdomen 7.2 mm long, 1.9 mm wide; mandibles 3.8 mm; first leg, femur 9 mm, patella 1.1 mm, tibia 9 mm, metatarsus 10 mm, tarsus 2 mm.

Cephalothorax, legs, eyes and sternum as in the male. The mandibles are longer than the cephalothorax. The upper margin of the furrow has 12 teeth, the two nearest the apex far apart, the rest evenly spaced. The lower margin has 13 teeth, the apical tooth much the largest and projecting straight forward, the six teeth nearest the base minute. The fang is sinuous, does not have a tooth at the base, and is darker in color than the mandible.

The abdomen is like that of the male, except that it is larger.

South America: Colombia, March, 1 ♂ 2 ♀ (J. T. Lloyd); Bello Horizonte, State of Minas Geraes, Brazil, Nov., 1 ♂ (Cornell University Expedition); São Paulo, Brazil, 1 ♂ (Hammar); Alta Parana river, Argentina-Paraguay, Jan., 1 ♂.

Also reported from the Island of St Vincent by Simon; from Lares, Porto Rico, Jan. 25, 1 ♀ by Banks (1901); from San José, La Verbena, San Joaquin, and Tejar de Cartāgo, Costa Rica, by Banks (1909); from Puerto Escondido, Lower California, June 14, 1 ♂ by Chamberlin (1924).

### Tetragnatha banski McCook

*Tetragnatha banski* McCook. American Spiders, 3:262, pl. 25, fig. 6, pl. 28, fig. 4. 1893

*Tetragnatha banski* Banks. Acad. Nat. Sci. Phila. Proc. 1904, p. 132.

*Tetragnatha banski* Petrunkevitch. Am. Mus. Nat. Hist. Bul. 29:389. 1911

This species has not been seen by me and therefore I give no description of it. The female has never been described.

McCook took it in Florida and Wisconsin. Banks reports it from Runnymede, Fla., in November, by sweeping herbage.

### **Tetragnatha caudata** Emerton

Plate 1, figures 5–10

* Lizard spider Abbot. Georgia Spiders, p. 39, fig. 496 (unpublished drawings)
*Tetragnatha lacerta* Walckenaer. Ins. Apt. 2:224. 1837 (invalid)
*Tetragnatha caudata* Emerton. Conn. Acad. Sci. Trans. 6:335, pl. 39, fig. 16, 22. 1884
*Eucta caudata* Marx. U. S. Nat. Mus. Proc. 12:552. 1889
*Tetragnatha caudata* Banks. Acad. Nat. Sci. Phila. Proc. 1892, p. 51
*Eucta caudata* Banks. N. Y. Ent. Soc. Jour. 1:132. 1893
*Eucta lacerta* McCook. Amer. Spiders, 3:266, pl. 24, fig. 5, 6, pl. 28, fig. 5. 1893.
*Eucta caudata* Britcher. Onondaga Acad. Sci. Proc. 1:127. 1903
*Eucta caudata* Banks. Acad. Nat. Sci. Phila. Proc. 1904, p. 132
*Tetragnatha caudata* Bryant. Bost. Soc. Nat. Hist. Paper 7:46. 1908
*Eucta caudata* Banks. U. S. Nat. Mus. Bull. 72:36. 1910
*Eucta lacerta* Petrunkevitch. Am. Mus. Nat. Hist. Bul. 29:339. 1911
*Eucta caudata* Comstock. Spider Book, p. 415, fig. 428. 1912
*Tetragnatha caudata* Banks. Acad. Nat. Sci. Phila. Proc. 68:78. 1916
*Eucta caudata* Emerton. Ent. News, 28:60. **1917**
*Tetragnatha caudata* Emerton. Roy. Canad. Inst. Trans. 12:320. 1919

*Male.* Total length (exclusive of chelicerae) 8 mm; cephalothorax 2.2 mm long, 1.2 wide; abdomen 6 mm long, 0.9 mm wide; mandibles 1.2 mm; palpus, femur 1.3 mm, patella 0.3 mm; tibia 0.3 mm, bulb 0.2 mm wide; first leg, femur, 6 mm, patella 1 mm, tibia 7 mm, metatarsus 7 mm, tarsus 1.5 mm.

Cephalothorax of even height, broadest in the middle, constricted where thoracic furrows reach the margin, marked with two parallel longitudinal dusky lines. The anterior row of eyes is straight, but the posterior row is strongly recurved, thus bringing the median eyes of each side nearer together than the lateral. The anterior median are closer together than the posterior median. The posterior median are the largest, the anterior lateral the smallest of the eyes. The chelicerae are about one-half as long as the cephalothorax; the upper margin has seven teeth, a moderately large tooth about two-thirds of the distance from base to apex, two small teeth cephalad of this and four more between it and the base diminishing in size toward the base; on the lower margin there are six teeth, the largest near the base of the fang, the rest small. The dorsal spur is not bifid, but has a

* This character indicates that I have not had access to the original reference to verify it.

minute tooth a short distance from the apex. The sternum has a dark border. There are but few spines on the legs.

The abdomen is long and narrow, no perceptible taper, prolonged beyond the spinnerets. The base is notched. In color it is silvery with a dark median line and dark reticulations and sometimes has a reddish tint. The venter is somewhat darker.

*Female.* Total length (exclusive of chelicerae) 9 mm; cephalothorax 2 mm long, 1 mm wide; abdomen 7.1 mm long, 1 mm wide, "tail" 2.1 mm long; mandibles 1 mm; first leg, femur 4.9 mm, patella 1 mm, tibia 4.7 mm, metatarsus 5 mm, tarsus 1.3 mm.

Cephalothorax highest at the eyes, broadest in the center constricted at thoracic furrows, marked with two parallel longitudinal dusky lines. Eyes as in male. Both margins of furrow of chelicerae with five small teeth. Sternum and legs as in male.

Abdomen long and slender, pointed behind, notched at base. The "tail" is from one-third to one-fifth the length of the abdomen. Marked as in male.

New York: Saranac, Aug., 1 ♀; Long Branch, Onondaga county, Sept., 4 ♀ (Britcher); Sodus Bay, Wayne county, Sept., 5 ♀ (Bishop); Point Breeze, Orleans county, June, 6 ♂ 7 ♀ (Crosby); Cinnamon lake, Schuyler county, Sept., 12 ♀; Ithaca, Aug. 5 ♀.

Georgia: Okefinokee swamp, June, 1 ♀ (Crosby).

Florida: Sorrento, Feb., 1 ♀; Manatee county, Jan., 1 ♂ 3 ♀; Cedar Keys, July, 1 ♀ immature (Hubbell); Belle Glade, Mar., 1 ♀ (Leonard). Tampa, July, 2 ♀ (Stone).

Mississippi: Ocean Springs, Jan., 2 ♀ (Comstock).

Minnesota: Minneapolis, 1 ♀ (Fletcher).

Indiana: Vowter Park, June, 1 ♀.

This species is also reported by Bryant (1908) from Maine: Dexter. By Emerton (1884) from Massachusetts: Malden and Dedham. By Emerton (1917) from New York: Saranac. By Walckenaer (1837) from Georgia, July (Abbot). By Emerton (1919) from Canada: Grand Beach, Lake Winnipeg, and Prince Albert, Saskatchewan.

This seems to be a rather rare species, judging from the number of specimens in our collection. It is distributed from Canada to Florida and west to Minnesota. It is a water-loving species. I have taken it by sweeping vegetation that hangs low over the edges of a boggy pond.

## **Tetragnatha elongata** Walckenaer

Plate 1, figures 11–13; plate 2, figures, 14–16

* *Aranea gibba* Bosc. MSS. sur les araignées de la Caroline., pl. 5, fig. 5 (unpublished)

*Tetragnatha elongata* Walckenaer. Tabl. Aran. p. 69. 1805 (invalid)
*Tetragnatha elongata* Walckenaer. Hist. Nat. Ins. Apt. 2:211. 1837
*Tetragnatha fulva* Walckenaer. Hist. Nat. Ins. Apt. 2:212. 1837
*Tetragnatha fimbriata* Walckenaer. Hist. Nat. Ins. Apt. 2:213. 1837
*Tetragnatha violacea* Walckenaer. Hist. Nat. Ins. Apt. 2:218. 1837
*Tetragnatha armigera* Blackwall. Ann. & Mag. Nat. Hist. 17:81. 1846
*Tetragnatha grallator* Hentz. Bost. Jour. Nat. Hist. 6:26, pl. 4, figs. 1, 2. 1850
*Tetragnatha grallator* Keyserling. Zool.-bot. Ges. Wien. Verh. 15:850, pl. 21, figs. 24–27. 1865
*Tetragnatha grallator* Hentz. Bost. Soc. Nat. Hist. Occas. Pap. 2:131, pl. 15, figs. 1, 2. 1875
*Tetragnatha elongata* Thorell. U. S. Geol. Surv. Bul. 3, no. 2:477. 1877
*Tetragnatha grallator* Emerton. Conn. Acad. Sci. Trans. 6:334, pl. 39, figs. 1–6. 1884
*Tetragnatha grallator* McCook. Acad. Nat. Sci. Phila. Proc. 1888, p. 79
*Tetragnatha elongata* Marx. U. S. Nat. Mus. Proc. 1889, p. 552
*Tetragnatha elongata* McCook. Am. Spid. 2:365. 1890 (mimicry)
*Tetragnatha elongata* Marx. Ent. Soc. Wash. Proc. 2:195. 1890
*Tetragnatha grallator* Banks. Acad. Nat. Sci. Phila. Proc. 1892, p. 51
*Tetragnatha elongata* McCook. Am. Spid. 3:260, pl. 25, figs. 1, 2. 1893
*Tetragnatha grallator* Banks. N. Y. Ent. Soc. Jour. 1:131. 1893
*Tetragnatha grallator* Banks. N. Y. Acad. Sci. Ann. 8:426. 1895
*Tetragnatha grallator* Banks. N. Y. Ent. Soc. Jour. 3:89. 1895
*Tetragnatha grallator* Banks. Ent. Soc. Wash. Proc. 4:189. 1897
*Tetragnatha grallator* Banks. Calif. Acad. Sci. Proc. (3) 1:246. 1898
*Tetragnatha grallator* Slosson. N. Y. Ent. Soc. Jour. 6:248. 1898
*Tetragnatha grallator* Banks. Acad. Nat. Sci. Phila. Proc. 1900, p. 563
*Tetragnatha grallator* Banks. U. S. Nat. Mus. Proc. 23:585. 1901
*Tetragnatha elongata* Tullgren. Bih. Svenska Ak. 27 Afd. 4, no. 1. 1901
*Tetragnatha grallator* Emerton. Common Spiders, p. 200, figs. 461, 465. 1902
* *Tetragnatha elongata* Britcher. Onondaga Acad. Sci. Proc. 1:127. 1903
*Tetragnatha grallator* Banks. Acad. Nat. Sci. Phila. Proc. 1904, p. 132
*Tetragnatha elongata* Scheffer. Kans. Acad. Sci. Trans. 19:11. 1905
*Tetragnatha grallator* Banks. Dept. Geol. & Nat. Res. Indiana. Rept. 31:739. 1906
*Tetragnatha grallator* Bryant. Bost. Soc. Nat. Hist. Paper 7:47. 1908
*Tetragnatha grallator* Banks. U. S. Nat. Mus. Bul. 72:37. 1910
*Tetragnatha grallator* Banks. Acad. Nat. Sci. Phila. Proc. 63:449. 1911
*Tetragnatha elongata* Petrunkevitch. Am. Mus. Nat. Hist. Bul. 29:390. 1911
*Tetragnatha elongata* Comstock. Spider Book. p. 411, fig. 424, 425. 1912
*Tetragnatha grallator* Emerton. Appalachia 12:155. 1912
*Tetragnatha elongata* Lutz. N. Y. Acad. Sci. Ann. 26:88. 1915
*Tetragnatha grallator* Strand. Archiv. f. Naturges. 1915, p. 97
*Tetragnatha grallator* Barrows. Ohio Jour. Sci. 18:307. 1918

*Male*. Total length (exclusive of chelicerae) 7.5 mm; cephalothorax 2 mm long, 1.8 mm wide; abdomen 6 mm long, 1.4 mm wide near base; mandibles 3 mm long; first leg, femur 11 mm, patella 1.2 mm, tibia 12 mm, metatarsus 14 mm, tarsus 3 mm; palpus, femur 3.1 mm, patella 0.8 mm, tibia 1.2 mm.

The cephalothorax is highest at the posterior eyes, the furrows well defined, reddish brown with sooty markings along the edges and the furrows (these markings are sometimes lacking). The chelicerae are unusually highly developed and exceed the cephalothorax in length. The upper margin of the furrow is provided with nine or ten teeth, the outermost at the base of the fang, a large prominent tooth two-thirds of the distance from base to apex, a very small one between these two teeth, and six or seven more caudad of the large tooth diminishing in size toward the base. The lower margin of the furrow has about 13 teeth, two near the base of the fang the largest (the second of these two larger than the first), the rest all small. Near the tip on the dorsal side of the mandible there is a prominent and bifid spur. The fang is not evenly curved, but undulates from its base to apex.

The anterior row of eyes is recurved; the posterior row but slightly so, making the distance between the lateral eyes of each side less than the distance between the anterior and posterior median. Anterior median slightly closer together than the posterior median. Posterior median slightly the largest of the eyes, the anterior lateral the smallest. Labium varying from light reddish to almost black. Sternum light reddish, sometimes with no markings, sometimes with more or less black around the edges. The legs are very long and well provided with spines, light reddish in color.

The abdomen is not swollen at the base, but tapers from base to apex, the base not notched. In general color and markings it resembles the abdomen of the female, but is lighter, being silvery with darker markings, a black longitudinal line on the ventral side.

*Female*. Total length (exclusive of chelicerae) 9 mm; cephalothorax 3 mm long, 1.8 mm wide; abdomen 7 mm long, 2.4 mm wide near the base; mandibles 2 mm; first leg, femur 8 mm, patella 1.2 mm, tibia 8 mm, metatarsus 8 mm, tarsus 2 mm.

The cephalothorax, legs, and chelicerae are light reddish brown in color. The cephalothorax sometimes has blackish markings as in the male. The chelicerae are almost as long as the cephalothorax; the upper margin of the furrow has eight teeth, the lower has 11. At the end of the mandible there are four or five blunt projections. The fang is sinuate and has a broad blunt tooth at the base on the

outer side. The legs are very long and spined. The eyes, endites and sternum are as in the male.

The abdomen is swollen near the base, thence tapering to the apex. The base is not notched. In coloration it is dull silvery with brownish markings and reticulations. There is a more or less distinct brownish folium on an indistinct brownish band mottled with dull silver which reaches from base to apex, margined with an uneven, wavy, broken line of black. Outside of this there is a wavy line of silver with brown reticulations. There is a black longitudinal median band on the venter; each side of this and extending around the sides of the abdomen is brown with small silver spots. On each side of the spinnerets is a white spot. These markings vary in distinctness in different specimens. The brown is sometimes almost black and sometimes a bright reddish brown. The relative areas of the various markings also varies.

New York: Adirondack Lodge, Essex county, July, 1 ♀ (Bishop); Old Forge, Herkimer county, July, 1 ♂ 2 ♀ (F. C. Paulmier); Trenton Falls, Oneida county, June 1 ♂ (Crosby); Wells, Hamilton county, July, 1 ♂ 2 ♀ (D. B. Young); Beaver river, Herkimer county, July, 1 ♂ (F. H. W.); Clyde, Wayne county, July, 2 ♂ 2 ♀, Aug., 1 ♀ (Bishop); Lake Bluff, Aug., 1 ♀ (Bishop); Warsaw, Aug., 1 ♀; Oak Ridge, Canandaigua lake, Aug., 2 ♀ (Bishop); Cinnamon lake, Schuyler county, July 1 ♂ (Crosby); Ithaca, July, 2 ♂ 2 ♀, Aug., 3 ♂ 4 ♀, Sept., 1 ♂, Oct., 7 ♀; McLean, Tompkins county, June, 1 ♀ (Palmer); Valcour island, Lake Champlain, Aug. 5 ♀, (Bishop); Elizabeth island, Lake George, July, 2 ♀ (Bishop); Pearl point, Lake George, July, 2 ♂ 3 ♀, Aug., 1 ♂ 2 ♀, Sept., 1 ♀ (Bishop); Voorheesville, Albany county, June, (Bishop); July, 1 ♂ 1 ♀ (M. D. Leonard), Aug., 1 ♀ (Bishop); Kattskill bay, Warren county, Aug., 1 ♂ (Bishop); Cossayuna lake, Washington county, May, 1 ♂ (W. J. Schoonmaker); Kinderhook, June, 1 ♀ (Paulmier); Sept., 2 ♀; Burden lake, Rensselaer county, July, 1 ♀ (Schoonmaker); Tackawasick pond, Rensselaer county, June, 1 ♀, May, 1 ♀; Ashokan, Ulster county, July, 2 ♀, Aug., 4 ♀ (Treadwell); Saugerties, Sept., 1 ♂; Cold Spring Harbor, Suffolk county, June, 1 ♂ (C. W. Davis), July, 1 ♂ (M. Gordon); Rockaway Beach, Queens county, Sept.. 1 ♂ 1 ♀ (Pike).

New Hampshire: Hollis, Aug., 1 ♂ 1 ♀ (Fox).

Pennsylvania: Arendtsville, Aug., 1 ♂ (S. W. Frost) (from stomach of *Rana pipiens*).

District of Columbia: 1 ♂ 1 ♀ (Marx), May, 1 ♂ 1 ♀ (Fox), Aug., 2 ♂ (Fox), Sept., 1 ♂ 1 ♀ (Fox).

North Carolina: Lake Waccamaw, Oct., 1 ♀ (Bishop and Crosby)

Georgia: Okefinokee swamp, June, many ♂ ♀ (Crosby); Camp Pickney, Charlton county, June, 1 ♀ (Wright); Toccoa, Aug., 1 ♀ (Bishop and Crosby).

Florida: Miami, Mar., 3 ♀ imm. (Comstock); Micanopy, May, 1 ♀ (Hubbell); Orlando, May, 1 ♀ (M. D. Leonard), June, 2 ♂ (M. D. Leonard), Aug., 1 ♂ 1 ♀ (McBride), Sept., 1 ♂ 1 ♀ (McBride), Lower Apalachicola river, April, 1 ♀ (Crosby); Tallahassee, April, 1 ♀ (Crosby); Rock Bluff, April, many ♂ ♀ (Crosby); Dead lake, April, many ♂ ♀ (Crosby).

Alabama: Holt, Tuscaloosa county, July, 1 ♀; St Clair county, June, 3 ♂ 1 ♀ (H. H. Smith); Woodstock, Jefferson county, June, 1 ♂ (H. H. Smith).

Mississippi: Agricultural College, Aug., 1 ♀, Oct., 1 ♀ (Bailey); Oxford, Aug., 1 ♂.

Louisiana: 2 ♂; Baton Rouge, Mar., 2 ♀; A. & M. College, 1 ♀; Chastine, May, 1 ♀ (K. P. Schmidt).

Texas: 1 ♀.

Ohio: Gambier, Aug., 1 ♂.

Kentucky: Quicksand, July 2 ♀ (Giovannoli); Clifton, June, 1 ♀ (Funkhouser).

Tennessee: Knoxville, 1 ♂ 3 ♀; Beersheba, July, 1 ♂ 3 ♀ (Fox).

Michigan: Douglas lake, July, 2 ♂ 2 ♀ (R. Matheson).

Illinois: Belleville, Aug., 3 ♂ 3 ♀ (Crosby).

Wisconsin: Aug.-Sept., 3 ♀ imm. (C. Bues).

Missouri: Columbia, 1 ♂ 8 ♀, July, 1 ♀, Sept., 3 ♂ 2 ♀ (Crosby); Hollister, April, 1 ♂ (H. H. Knight); Creve Coeur lake, Aug., 1 ♂ 1 ♀ (Crosby).

Kansas: Douglas county, July, 20 ♂ 2 ♀.

Nebraska: Union, Aug., 1 ♀ (G. Pickwell); Valentine, Aug., 3 ♂ 7 ♀ (G. Pickwell).

Oregon: Corvallis, Oct., 1 ♀ (H. E. Ewing).

Washington: Lake Sutherland, Aug., 5 ♀ (Crosby).

This species is also reported by Bryant (1908) from Maine: Portland; New Hampshire: Lake Winnepesaukee and Franconia; Massachusetts: Beverly, Peabody, Sharon, Mount Tom, and Warwick. By Banks (1895) from New York: Near Sea Cliff, Long Island. By Banks (1911) from North Carolina: Durham, Murphy, Linville, Paint Rock, Swannanoa valley. By Tullgren (1901) from Florida. By Banks (1900) from Alabama: Auburn. By Banks (1897) from Louisiana. By Barrows (1918) from Ohio: Columbus, May, Rockbridge, July, Buckeye Lake, June, and Cedar Point. By

Banks (1906) from Indiana: Tippecanoe lake, June, Arlington, June, Kosciusko county, and Huntingburgh. By Scheffer (1905) from Kansas: Manhattan, Aug., and Stockton, Aug. By Banks (1901) from Arizona: Santa Rita Mountains. By Banks (1895) and Thorell (1877) from Colorado: Boulder, Manitou, Golden and Steamboat Springs. By Thorell (1877) from Idaho, July, and Utah: Great Salt lake, July. By Banks (1898) from Lower California: Sierra Laguna and San Jose del Cabo. By Blackwall (1846) from Canada: Toronto. By Marx (1890) from the Arctic Region: Sitka and Unalaska. By Keyserling (1865) and Strand (1915) from South America: Colombia.

This is a variable and common species. Its distribution is from coast to coast and from Mexico to the Arctic region, and it is reported from South America. It inhabits wet places, frequently building its web on branches that hang out over running or stagnant water. Walckenaer probably described this species under several different names, but it is impossible to straighten out his nomenclature without the aid of Abbot's drawings from which he wrote his descriptions. I have therefore omitted his names from the synonymy. McCook (1893), who claims to have studied these manuscript drawings, considers Walckenaer's *T. fulva*, *T. fimbriata*, and *T. violacea* as synonyms of *T. elongata*.

## **Tetragnatha extensa** Linnaeus

Plate 2, figures 17–20

*Araneus* ex *viridi inauratus* . . . Lister. Hist. Animal. Angl. p. 30, pl. 1 fig. 3. 1678

*Aranea abdomine longo argenteo viriscente* Linnaeus. Faun. Suec. p. 351. 1746

*Aranea extensa* Linnaeus. Syst. Naturae 10th ed. 1:621. 1758

*Aranea extensa* Linneaus. Faun. Suec. p. 489. 1761

L'araignée à ventre cylindrique & pattes de devant étendues Geoffroy. Hist. des Insect. aux Environ. de Paris. 2:642. 1762

*Aranea mouffeti* Scopoli. Ent. Carn. p. 398. 1763

*Araignée patte-étendue* De Geer. Mém. Hist. des Insect. 7:236

(No name). Roewer. Gen. Insect. Linnei et Fabricii pl. 30, fig. 6. 1789

*Aranea extensa* Fabricius. Spec. Insect. 1:536. 1781

*Aranea extensa* Fabricius. Ent. Syst. p. 407. 1793

*Aranea extensa* Walckenaer. Faun. Paris. 2:204. 1802

*Arenea extensa* Latreille. Hist. Nat. Crust. & Insect. 7:249. 1804

**Aranea prima* Schaeffer. Icones Insect. circa Ratisbon Indig., pl. 49, fig. 9. 1804

**Aranea secunda* Schaeffer. Icones Insect. circa Ratisbon Indig., pl. 49, fig. 8. 1804

**Aranea quarta* Schaeffer. Icones Insect. circa Ratisbon Indig. pl. 119, fig. 9. 1804

*Tetragnatha extensa* Walckenaer. Tabl. des Aran. p. 68, pl. 7, fig. 63 & 64. 1805
*Tetragnatha extensa* Latreille. Gen. Crust. et Insect. 1:101, pl. 4, fig. 4. 1806
* *Tetragnatha extensa* Walckenaer. Hist. Nat. des Aranéides, p. 5. 1806–8
*Aranea extensa* Rossi. Fauna Etrusca 2:203. 1807
*Tetragnatha extensa* Latreille. Consid. Général. des Animaux, p. 424. 1810
* *Tetragnatha extensa* Risso. Hist. Nat. Princ. Prod. de l'Europe. 5:168. 1826
* *Tetragnatha rubra* Risso. Hist. Nat. Princ. Prod. de l'Europe. 5:168. 1826
*Tetragnatha extensa* Hahn. Arachn. 2:43, pl. 56, fig. 129. 1832
*Tetragnatha extensa* Sundevall. K. Svenska Vet. Akad. Hdl. 1832, p. 256
*Tetragnatha extensa* Duges. Régn. Animal. 15:52, pl. 10, fig. 5. 1836
*Tetragnatha extensa* Koch. Ubers. des Arachn. 1:5. 1837
*Tetragnatha gibba* Koch. Ubers. des Arachn. 1:5. 1837
*Tetragnatha extensa* Walckenaer. Hist. Nat. Ins. Apt. 2:203. 1837
*Tetragnatha épéirides* Walckenaer. Hist. Nat. Ins. Apt. 2:223. 1837
* *Tetragnatha extensa* Contarini. Cataloghi Insetti, p. 15. 1843
*Tetragnatha extensa* Heer und Blumer-Heer. Der Kanton Glarus, p. 213. 1846
*Tetragnatha extensa* Contarini. Venezia e le sue Lagune 2:163. 1847
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*Male.* Total length (exclusive of chelicerae) 5.2 mm; cephalothorax 2.1 mm long, 1.2 mm wide at center; abdomen 3 mm long, 1.1 mm wide; chelicerae 1.5 mm long; first leg, femur 4.8 mm, patella 1 mm (on outer side), tibia 5.5 mm, metatarsus 4.6 mm, tarsus 1.4 mm; palpus, femur 1.2 mm, patella 0.3 mm, tibia 0.7 mm.

Cephalothorax of same height throughout, widest at center, constricted where thoracic furrow reaches the margin. Light reddish brown with darker markings on the edges and the furrows (but these are sometimes lacking). Chelicerae not so well developed as in *T. elongata*, shorter than cephalothorax, the upper margin of furrow with eight teeth, the outermost tooth at the base of the fang, a large prominent tooth two-thirds of the distance from base to apex, and between this large tooth and the apex there is a low blunt tooth; five more teeth are arranged in a row between the large tooth and the base of the mandible and diminishing in size toward the base. The lower margin has eight or nine teeth, all very small. Near the tip on the upper side of the mandible there is a prominent spur that is bifid. The fang is evenly curved, or at most but slightly sinuate. Both rows of eyes are recurved, but the anterior row is more so than the posterior row, thus bringing the lateral eyes closer together than are the medians of each side. Anterior medians slightly closer together than the posterior medians; the latter are slightly the largest of the eyes. Sternum lighter than the dorsum. Labium dark.

The abdomen tapers slightly from base to apex, the base not notched. In color and markings very variable, resembling in general the female.

*Female.* Total length (exclusive of chelicerae) 6.5 mm; cephalothorax 2.1 mm long, 1.5 mm wide; abdomen 4.8 mm long, 2 mm wide near base; chelicerae 1.4 mm long; first leg, femur 5 mm, patella 1 mm, tibia 5 mm, metatarsus 5.5 mm, tarsus 1.5 mm.

Cephalothorax slightly highest at the eyes, marked as in male. Chelicerae little more than half as long as cephalothorax, the upper

margin of furrow with seven teeth, the outermost at the base of the fang the largest, then, after an interval, six more diminishing in size toward the base; the lower margin has seven or eight teeth, those in the middle of the row the largest. Fang evenly curved and with a broad blunt tooth on the outer side near the base.

Eyes, sternum, endites and labium as in male.

Abdomen swollen near the base, thence tapering to apex. Base overhangs the thorax and is slightly notched. The coloration of the abdomen varies so much that it is difficult to describe it comprehensively. There are hardly two specimens colored exactly alike. It is usually silvery with grayish, reddish, brownish or black reticulations and markings. In one specimen there is a reddish tinted band on top of the silver, from base to apex of the dorsum. On this band there is a very distinct folium of dark gray color. At the edges of this reddish band, which is very uneven and undulating, the color is more intensely red. A grayish longitudinal band occupies the middle of the venter, alongside of this and extending around the sides of the abdomen is silver tinted with light red and with grayish reticulations. In another specimen a broad, bright red band begins at the apex of the dorsum and runs forward almost half the length of the abdomen when it splits to enclose a narrow band of silver for the rest of the distance. An indistinct folium is present. The sides of the abdomen are silvery with dark reticulations and have a narrow band of red extending most of the length. The venter has a black longitudinal band surrounded on each side by a narrow band of silver with reddish tint, with a band of dark red outside of this. Another specimen is silvery, reticulated with gray, a distinct folium on the dorsum, and six reddish blotches, one on either side of the slight notch at the base, a large one on either side near the middle, and two smaller ones near the apex. The venter has a light gray median band. The sides of the abdomen are silvery. The silver everywhere is tinted indistinctly and unevenly with light red. These specimens are all from the same place and taken at the same time. In other specimens the red is replaced by gray, dark reddish brown, or black. A few specimens have a faint dark green tint to these markings. In some specimens the silver is not reticulated in certain areas. The silver, too, is sometimes replaced by white. The relative areas of the markings also vary to a great extent. The species is never so brilliantly silvery as *T. laboriosa,* however.

New York: Summit Mount McIntyre, Essex county, June, 2♂ (Bishop); Keene Valley, Essex county, June, 1♂ (Notman); Adiron-

dack Lodge, Essex county, June, 1 ♂ 1 ♀, July, 2 ♂ 6 ♀ (Bishop); Artist brook, Essex county, June, 1 ♂ 1 ♀ (Bishop); Chapel pond, Essex county, June, 1 ♂ 1 ♀ (Bishop); Avalanche lake, Essex county, July, 1 ♀ (Bishop); Newcomb, Essex county, July, 1 ♂ 1 ♀, Sept., 2 ♀ (House); Speculator, Hamilton county, June, 1 ♀, (D. B. Young), July, 2 ♂ 1 ♀ (D. B. Young); Wells, July, 1 ♂ 2 ♀ (D. B. Young); Paul Smiths, Franklin county, July, 5 ♀ (F. C. Paulmier); Old Forge, Herkimer county, July, 1 ♀ (Paulmier); Aug., many ♀ (Needham); Michigan Mills, Lewis county, Sept., 2 ♀; Trenton Falls, June, many ♂ ♀; Oneida lake, Aug., 2 ♂ 4 ♀ (House); Johnstown, Fulton county, Aug., 1 ♀ (Alexander); Apulia, Onondaga county, Oct., 2 ♀ (Britcher); Long Branch, Onondaga county, Sept., many ♀ (Britcher); Tully, Onondaga county, Oct., 7 ♂ 9 ♀ (Britcher); Jamesville, Onondaga county, Oct., 1 ♀ (Britcher); Baldwinsville, Onondaga county, Sept., many ♀. (Britcher); Sodus Bay, Wayne county, Sept., many ♀ (Bishop); Hemlock lake, Livingston county, Aug., 3 ♀; Letchworth park, Wyoming county, July, 1 ♂ 2 ♀; Chautauqua county, 1 ♂ (Palmer); Penn Yan, July, 1 ♂ (Babiy); Howard, Steuben county, July, 1 ♀; Cinnamon lake, Schuyler county, June, 8 ♀, July, 5 ♂ 2 ♀ (Crosby); Montour Falls, Schuyler county, Sept., 1 ♀, Oct., 1 ♀; Alpine, Schuyler county, Nov., 5 ♀; Crocketts, Cayuga county, Sept., 3 ♀ (Chapman); Owasco lake, Nov., 1 ♀; Enfield glen, Tompkins county, May, 8 ♀; Taughannock, Tompkins county, Aug., 1 ♀; Glenwood, Tompkins county, Aug., 1 ♀; Ithaca, June, 1 ♂ 1 ♀, July, 3 ♂ 10 ♀, Aug., 4 ♀, Sept., 1 ♀, Oct., 1 ♀; Caroline Center, Tompkins county, May, 1 ♂ 1 ♀; McLean, Tompkins county, May, 2 ♂ 1 ♀, June, 1 ♂ 1 ♀, July, 1 ♂ 1 ♀ (Crosby and Bishop); Freeville, Tompkins county, Sept., 2 ♀; Ringwood, Tompkins county, July, 2 ♀; Labrador pond, Cortland county, May, 1 ♀ (Tarris), June, 1 ♂; Deruyter lake, Madison county, July, 2 ♂ 2 ♀; Valcour island, Lake Champlain, Aug., 2 ♂ 2 ♀ (Bishop); Juanita island, Lake George, July, 1 ♂ (Bishop); Tongue Mountain, Warren county, Sept., 4 ♀; Pearl point, Lake George, July, 1 ♀ (Bishop); Shelving Rock mountain, Washington county, July, 1 ♂ 1 ♀ (Bishop); Shelving Rock brook, Sept., 1 ♀; Bumps pond, Washington county, July, 1 ♂; (Bishop and Crosby); Cossayuna lake, May, 3 ♀ (Schoonmaker); Thompsons lake, Albany county, Sept., 5 ♀ (G. H. C.); Mud Hollow pond, Albany county, June, 1 ♂ 3 ♀ (Bishop); Voorheesville, June, 1 ♀ (Bishop); July, 1 ♂ 1 ♀ (Leonard); East Berne, Albany county, June, 1 ♀ (Bishop); Waldorf, Albany county, Oct., 1 ♀ (D. B. Young); Tackawasick pond, Rensselaer county, June, 1 ♀ (Crosby and Bishop); Poestenkill, Rensselaer county,

June, 1 ♂ 1 ♀ (Young); Hunter, Greene county, Aug., 3 ♀; Kinderhook, Columbia county, June, 1 ♀ (C. A. Brown), Aug., 1 ♀ (Schoonmaker); Riders Mills, Columbia county, May, 1 ♂ 1 ♀ (Bishop); Lake Charlotte, Columbia county, June, 1 ♀, Sept., (F. C. Paulmier); Wappingers Falls, Dutchess county, May, 6 ♀ (Bishop and Crosby); Ashokan, Ulster county, Aug., 1 ♀ (Treadwell); Lake Katrine, Ulster county, Sept., 1 ♀; Oakland Valley, Sullivan county, May, 1 ♀ (Bishop and Crosby); Pine kill, Sullivan county, May, 2 ♀; Long pond, Suffolk county, June, 1 ♀; Smithtown, June, 1 ♂ (Leonard).

Maine: Isle-au-Haut, July, 3 ♀ (Bishop).

New Hampshire: Hollis, Aug., 1 ♀ (Fox); Carroll, June, 2 ♀; Pike, June, 1 ♂.

Vermont: Newport, June, 1 ♂ 1 ♀.

District of Columbia: 1 ♂ 1 ♀ (Marx), May, 1 ♂ (Fox), July, 1 ♀ (Fox).

Virginia: Franklin, Oct., 1 ♀ imm.

Georgia: Okefinokee swamp, June, many ♂ ♀ (Crosby); Thomasville, May, 1 ♂ (Spencer); Black Rock mountain, Rabun county, May, 1 ♂ (2000–3000 feet elevation) (Bishop and Crosby).

Florida: Lake City, Mar., 1 ♀ (Comstock); Oneco, Dec., 1 ♀; Gainesville, Mar., 1 ♂ (Hubbell); Dead Lake, April, 3 ♀ (Crosby); Rock Bluff, April, 2 ♂ 10 ♀ (Crosby); Cotton Bluff, Calhoun county, April, 1 ♂ (Crosby); Micanopy, Mar., 4 immature (Leonard); 1 immature (Hubbell); Sanford, Sept., 2 ♂ (Stone).

Alabama: Auburn, July, 1 ♀.

Mississippi: Ocean Springs, Jan., 3 ♀ imm. (Comstock).

Louisiana: 1 ♀ (Gilbeau).

Texas: 1 ♂.

Ohio: Urbana, July, 1 ♀ (Nelson).

Kentucky: Noble, June, 1 ♀ (Giovannoli).

Tennessee: Knoxville, July, 1 ♀ (W. B. Cartwright); Laurel creek, Sevier county, Oct., 3 imm. (Bishop and Crosby); Mill creek, below Falls, Mount LeConte, Oct., 1 imm. (Bishop and Crosby).

Illinois: Belleville, Aug., 1 ♀.

Michigan: Douglas lake, July, 6 ♂ 8 ♀, Aug., 1 ♀ (R. Matheson).

Minnesota: Lake Minnetonka, Sept., 1 ♂ imm. (Fletcher), June 1 ♀ (Fletcher).

Missouri: Columbia, 1 ♀ (P. Hayhurst).

Montana: Bozeman, July, 1 ♀.

Wyoming: Yellowstone National Park, July, 3 ♀ (Muttkowski), Aug., 1 ♀.

Utah: Logan, June, 1♂ 1♀ (Needham); Wellsville, June, 1♀ (Needham).

Colorado: Pike's Peak, Aug., 2♀; Cascade, Aug., 1♀ (Crosby); Manitou, Aug., 1♀ (Crosby); Lake Moraisa, Oct., 2♀; Estes park, Aug., 7♀ (Claassen); Mummy Range, Aug., 2♀ (Crosby); Pingree park, Aug., 4♂ 16♀ (Crosby).

California: Claremont, May, 1♂ 4♀; San Miguel, 1♂ 3♀ (Oslar); Needles, Apr., 1♀; Harden's lake, Tuolumne county, 3♂ 1♀ (alt. 7575 feet); Stanford, Mar., 4♀; San Diego, 1♀ (from stomach of *Bufo boreas halophilus*) (T. H. Webb).

Oregon: Coast Range, Sept., 3♀; Portland, Jan., 1♀.

Washington: Lake Sutherland, Aug., 1♂ 15♀ (Crosby); Friday Harbor, July, 1♀.

Nova Scotia: Truro, June, 2♀, Aug., 3♂ 2♀.

Ontario: Point au Baril, Aug., 3♀ (L. Giovannoli).

This species is also reported by Emerton (1884) from Massachusetts, Connecticut, and the White mountains. By Slosson (1898) from New Hampshire: Franconia. By Emerton (1912) from New Hampshire: Lake Winnepesaukee. By Barrows (1918) from Ohio: Delaware, June, and Cedar Point, Aug. By Banks (1906) from Indiana: Tippecanoe lake, June, Vincennes, July, Grand Chain, July, Culver, June and Knox county, July. By Scheffer (1905) from Kansas: Douglas county, Mar.-July, and Clark county, June. By Banks (1902) from Arizona: Colorado Canyon, July, and Williams, June. By Banks (1901) from New Mexico: Beulah 1♂ 1♀, White Mountains 1♂. By Strand (1915) from Wyoming: Yellowstone Park. By Cockerell (1911) from Colorado: Boulder and Eldorado. By Banks (1904) from California: Laundry Farm, Alameda county, Apr. (Fuchs). By Coolidge (1910) from California: Alta, Placer county. By Moles (1921) from California: Alameda county. By Emerton (1895 and 1919) from Canada: Anticosti; Entry Island, Province of Quebec (S. Henshaw); Saskatchewan river (S. H. Scudder); Kettle Rapids, Manitoba; and Truro, Nova Scotia. By Fletcher (1908) from Canada: Little Current river, July. By Keyserling (1865) from the Mackenzie river, Canada. By Thorell (1875) from Labrador: Square Island, July. By Banks (1916) from British Columbia: Lardo, July (Dyar), Kaslo, June, July (Currie), Kaslo creek, June (Currie), Ainsworth, July (Currie), and Powder creek, June (Currie). By Banks (1900) from Alaska: Kadiak, July, Fox Point, July, Sitka, June, and Metlakahtla, June. By Cambridge (1879) from Great Britain: Generally distributed. By Simon (1874) from France: Everywhere. By Chyzer and Kul-

czynski (1891) from Austria Hungary: Numerous localities. By Jaquet (1898) from Roumania. By de Lessert (1910) from Switzerland: Numerous localities. By Schenkel (1926) from Switzerland (elevation 1900–2264 m.) By Canestrini and Pavesi (1868) and Sordelli (1868) from Italy. By Fage (1921) from Greece: Mikra. By Simon (1884) from Greece: Corfu and Athens. By Thorell (1875) from Russia: Kamienietz-Podolski, Radomysl, Jekaterinoslaw, Sudak, and Sarepta. By Kulczynski (1895) from Armenia and Transcaucasia. By Järvi (1916) from Finland: Hängo. By Marx (1890) from Lapland, Aleutian Islands, Commander Islands, and Siberia. By Simon (1887) and Fedotov (1912) from Lapland. By Simon (1891) from Siberia. By Becker (1896) from Belgium, Holland, Germany, Norway, Sweden, China, Japan, New Zealand, and Algeria. By Simon (1885) from Tunis. By Reimoser (1919) from the Azores.

This seems to be the commonest species of Tetragnatha in our fauna and is found in the same type of environment as *T. elongata.* It is distributed all over the Northern Hemisphere from Mexico and Northern Africa to Alaska, Labrador, Lapland and Commander islands, if the references to it in the literature are correct. It is a very common species all over Europe, and is reported from Algeria and Tunis in North Africa, Mesopotamia, Western Siberia, China, Japan, and New Zealand. In our own country I have seen specimens taken in nearly half the states and representing all parts of the country. In altitude they occur from near sea level (Long island) to above the timber line in Colorado and 7575 feet elevation in California. It is a very variable species and several writers have described varieties. Thorell (1870) divides the European forms into three varieties, *Forma T. extensa vera*, based on *Aranea extensa* Linnaeus, *Forma T. Solandri*, based on *Aranea Solandri* Scopoli, and *Forma T. obtusa*, based on *Tetragnatha obtusa* C. Koch. These last two forms are recognized as distinct species by modern writers. I have examined a few specimens of *T. obtusa* from Europe — 3 ♀ from Richard Hancock, England and 2 ♂ and 1 ♀ from Eugene Simon, France — and these are quite distinct from *T. extensa*, at least the males, the females being closely similar to females of *T. extensa*. The following specimens of *T. Solandri* have also been examined: 1 ♂ 1 ♀ from Mr Hancock, England, and 1 ♂ and 1 ♀ from Professor S. A. Spassky, Don, Russia. The males of these are also distinct. The following European specimens of *T. extensa* have been compared with native specimens and found to be identical: 1 ♂ 2 ♀ that were sent by Mr. Hancock, 1 ♂ 2 ♀ sent by M.

Simon, and 1 ♂ 1 ♀ from Professor Spassky. All the above-mentioned European specimens are in the Cornell University collection.

*T. extensa* has been known for a long time. In 1678 Martin Lister wrote a very good account of its life history. A more recent account of its life history is given by McCook (1890).

## **Tetragnatha laboriosa** Hentz

Plate 2, figures 25–29; plate 3, figures 30–31

*Tetragnatha laboriosa*. Hentz. Hitchcock's Report on the Geology of Mass. 2d ed., p. 31. 1835 (a list of names only)

*Tetragnatha laboriosa* Hentz. Bost. Jour. Nat. Hist. 6:27, pl. 4, fig. 3. 1850

*Tetragnatha laboriosa* Keyserling. Zool.-bot. Ges. Wien. Verhandl. 15:841, pl. 20, figs. 16, 17. 1865

*Tetragnatha laboriosa* Hentz. Bost. Soc. Nat. Hist. Occas. Papers 2:131, pl. 15, fig. 3. 1875

*Tetragnatha illinoiensis* Keyserling. Zool.-bot. Ges. Wien. Verhandl. 29:318, pl. 4, fig. 18. 1879

*Tetragnatha laboriosa* Emerton. Conn. Acad. Sci. Trans. 6:334, pl. 39, figs. 7, 8, 11, 19, pl. 40, fig. 7. 1884

*Tetragnatha laboriosa* Marx. Fourth Rep't U. S. Ent. Comm. p. 106 app. 1885

*Tetragnatha laboriosa* Marx. U. S. Nat. Mus. Proc. 12:552. 1890

*Tetragnatha laboriosa* Banks. Acad. Nat. Sci. Phila. Proc. 1892, p. 51

*Tetragnatha laboriosa* Banks. N. Y. Ent. Soc. Jour. 1:131. 1893

*Tetragnatha laboriosa* McCook. Amer. Spiders. 3:262, pl. 25, figs. 7, 8. 1893

*Tetragnatha laboriosa* Banks. N. Y. Acad. Sci. Ann. 8:426. 1895

*Tetragnatha laboriosa* Banks. N. Y. Ent. Soc. Jour. 3:89. 1895

*Tetragnatha laboriosa* Harrington. Ottawa Natural. 10:13. 1896

*Tetragnatha laboriosa* Banks. Ent. Soc. Wash. Proc. 4:189. 1897

*Tetragnatha laboriosa* Banks. Wash. Acad. Aci. Proc. 2:482. 1900

*Tetragnatha laboriosa* Banks. Acad. Nat. Sci. Phila. Proc. 1900, p. 536

*Tetragnatha laboriosa* Banks. U. S. Nat. Mus. Proc. 24:220. 1901

*Tetragnatha laboriosa* Banks. Acad. Nat. Sci. Phila. Proc. 1901, p. 581

*Tetragnatha laboriosa* Emerton. Common Spiders, p. 202, figs. 463, 467. 1902

**Tetragnatha laboriosa* Britcher. Onondaga Acad. Sci. Proc. 1:123–30. 1903

*Tetragnatha laboriosa* Banks. Calif. Acad. Sci. Proc. 3:350. 1904

*Tetragnatha laboriosa* Banks. Acad. Nat. Sci. Phila. Proc. 1904, p. 132

*Tetragnatha laboriosa* Banks. Dep't Geol. & Nat. Res. Indiana Rep't 31:739. 1906

*Tetragnatha laboriosa* Strand. Die arktischen Araneae, p. 451. 1906

*Tetragnatha laboriosa* Bryant. Bost. Soc. Nat. Hist. Paper 7:47. 1908

*Tetragnatha seydi* Strand. Jahrb. Nassau. Ver. Naturk. 61:230. 1908

*Tetragnatha laboriosa* Banks. U. S. Nat. Mus. Bul. 72:37. 1910

*Tetragnatha laboriosa* Banks. Acad. Nat. Sci. Phila. Proc. 63:449. 1911

*Tetragnatha laboriosa* Cockerell. Univ. Colorado Studies 8, no. 4:254. 1911

*Tetragnatha laboriosa* Petrunkevitch. Am. Mus. Nat. Hist. Bul. 29:391. 1911

*Tetragnatha laboriosa* Comstock. Spider Book, p. 412, figs. 419, 426. 1912

*Tetragnatha laboriosa* Emerton. Appalachia 12:155. 1912

*Tetragnatha laboriosa* Biking. Ohio Natural. 14:215. 1913
*Tetragnatha laboriosa* Lutz. N. Y. Acad. Sci. Ann. 26:88. 1915
*Tetragnatha laboriosa* Moles. Jour. Ent. Zool. 7:209, pl. 2 col. 1915
*Tetragnatha laboriosa* Banks. U. S. Nat. Mus. Proc. 51:69. 1916
*Tetragnatha laboriosa* Barrows. Ohio Jour. Sci. 18:307. 1918
*Tetragnatha laboriosa* Emerton. Roy. Canadian Inst. Trans. 12:321. 1919
*Tetragnatha laboriosa* Moles. Jour. Ent. Zool. 13:41. 1921

*Male.* Total length (exclusive of mandibles) 5 mm; cephalothorax 2 mm long, 1.1 mm wide; abdomen 3.1 mm long, 0.9 mm wide; mandibles 1.2 mm; first leg, femur 5 mm, patella 1 mm (outer side), tibia, 5 mm, metatarsus 5 mm, tarsus 1.3 mm; palpus, femur 1 mm, patella 0.2 mm, tibia 0.3 mm.

Cephalothorax slightly highest at posterior eyes, widest in center, constricted where thoracic furrows reach margin with sooty markings extending from median furrow to the posterior lateral eyes, and reddish along the margin (these markings are sometimes lacking). Chelicerae are one-half the length of cephalothorax, with sooty markings on front side sometimes. The upper margin of the furrow has nine teeth, a large prominent tooth two-thirds of distance from base to apex, two teeth between this large tooth and the apex, and six between it and the base diminishing in size toward base; on lower margin there are eight teeth. The dorsal spur is shallowly bifid. Fang evenly curved. The two rows of eyes are equally recurved, making the lateral and median on each side equidistant. Posterior eyes equidistant from each other and equal in size. Anterior median are larger than anterior lateral and closer together than posterior median. Sternum usually black around the edges, with a light reddish center. Labium dark. Legs light yellow in color, furnished with short spines, those on tibia I but twice as long as the thickness of the tibia.

Width of abdomen the same throughout its length, hardly overlapping the thorax, truncated at the base. Above it is silvery with darker reticulations and folium. On the venter a broad black band extends longitudinally, on each side of this there is a light band, and on the outside of this there is another dark band. The silver color is quite conspicuous in this species.

*Female.* Total length (exclusive of chelicerae) 6 mm; cephalothorax 2 mm; abdomen 4.2 mm; mandibles 1 mm; first leg, femur 4.1 mm; patella 1 mm, tibia 4 mm, metatarsus 4.3 mm, tarsus 1.5 mm.

Cephalothorax of even height, broadest at the center, slightly constricted where thoracic furrows reach the margin, marked as in male. Chelicerae short often with sooty markings on front and side.

Six teeth on upper margin of furrow, eight on lower margin. Fang evenly curved, no basal tooth. Eyes, sternum, and legs as in male. Spines on tibia I a little longer than the thickness of the tibia.

The abdomen is only about twice the length of the cephalothorax. It is usually smoothly oval in outline. It overhangs the thorax and is somewhat concave at the base. In color it is conspicuously silvery with a well defined folium on the dorsum. The venter has a black longitudinal median band with silvery lines on each side and another black line on each side of the silver lines.

New York: Black brook, Clinton county, June, 1 ♂ (Crosby); Peru, Clinton county, June, 1 ♂ (Crosby); Ausable river, Aug., 3 ♀; Mount McIntyre, Essex county, Aug., 1 ♀ (Bishop); Keene Valley, Essex county, July, 1 ♀ (Notman); Adirondack Lodge, Essex county, July, 3 ♂ (Bishop); Wilmington, Essex county, Aug., many ♂ ♀; Paul Smiths, Franklin county, July, 1 ♂ 3 ♀ (Babiy); Saranac Lake, Aug., 5 ♂ 9 ♀ (Paulmier); Wells, Herkimer county, June, 1 ♂ 2 ♀ (D. B. Young); West Winfield, Herkimer county, June, 1 ♂ (Crosby); Trenton Falls, Oneida county, June, 7 ♂ 3 ♀; Waterville, Oneida county, Aug., 1 ♂ (Crosby); Clayville, Oneida county, July, 1 ♀ (Crosby); Pinnacle Mountain, Bleeker, Fulton county, Sept., 1 ♀ (Crosby); Smithville, Jefferson county, Aug., 1 ♂ 1 ♀; Pompey, Onondaga county, Sept., 1 ♀ (Britcher); Onondaga Valley, Onondaga county, June, 1 ♀ (Britcher); Otisco, Onondaga county, Aug., 1 ♂ 4 ♀ (Britcher); Apulia, Onondaga county, Oct., 1 ♀ (Britcher); Lake Bluff, Wayne county, Sept., 1 ♀ (Bishop); Honeoye Falls, July, 2 ♀ (Crosby); Point Breeze, Orleans county, June, 2 ♀ (Crosby); Lakeside park, Orleans county, July, 2 ♂ (Crosby); Barre Center, Orleans county, June, 2 ♂ 1 ♀ (Crosby); Irving, Chautauqua county, Sept., 1 ♀ (Chadwick); Dunkirk, Chautauqua county, 2 ♂ 2 ♀ (Hayhurst); Penn Yan, Aug., 4 ♂ (Crosby); Cinnamon lake, Schuyler county, June, 3 ♂ 7 ♀, July 1 ♀, Sept., 3 ♀; Taughannock falls, Tompkins county, July, 2 ♂ (Crosby); Enfield glen, Tompkins county, May, 2 ♀; Ithaca 5 ♀, July, 2 ♂, Aug., 2 ♂ 3 ♀, Nov., 2 ♀; Ringwood, Tompkins county, July, 3 ♀ (Dietrich); Juanita island, Lake George, July, 1 ♂, Aug., 2 ♂ 2 ♀, Sept., 6 ♂ 2 ♀ (Bishop); Valcour island, Lake Champlain, Aug., 2 ♂ 1 ♀ (Bishop); Watervliet reservoir, Albany county, Aug., 2 ♂ 2 ♀ (M. D. Leonard); Mud Hollow pond, Albany county, June, 1 ♂ 1 ♀ (Bishop); Tackawasick pond, Rensselaer county, June, 2 ♂ 3 ♀ (Schoonmaker); Pike pond, Rensselaer county, June, 1 ♂ (Bishop); Columbia county, 1 ♀; Rhinebeck, Dutchess county, Oct., 1 ♂ (Bishop); Lagrangeville, Dutchess county, May, 1 ♀; Wappingers

Falls, Dutchess county, May, 1 ♀ (Crosby and Bishop); Stamford, Delaware county, June, 1 ♂ (Bishop); Sam's Point, Ulster county, May, 1 ♀ (Bishop); Kingston, Mar., 1 ♀ (Schoonmaker); Ashokan, Ulster county, Aug., 1 ♂ (Treadwell); Oakland valley, Sullivan county, May, 2 ♂ 2 ♀ (Bishop); Bergen Beach, Kings county, June, 1 ♀, Flatbush, Kings county, July, 1 ♂ 6 ♀ (Pike); Rockaway Beach, Sept., 1 ♂ 2 ♀ (Pike); Cold Spring Harbor, Suffolk county, June, 5 ♀ (E. G. Anderson); Shinnecock hills, Suffolk county, June, 1 ♀ (Crosby).

Maine: Sebasticook lake, Aug., 1 ♀ (Crosby); Falmouth, Aug., 1 ♀ (Crosby); Westbrook, 1 ♀ (Lathrop).

Massachusetts: Wood's Hole, July, 2 ♂ 4 ♀ (Britcher), Aug., 2 ♀ (Forbes), Sept., 1 ♀ (Forbes); Fitchburg, July, 1 ♂ (Fox).

New Hampshire: Hollis, Aug., 20 ♂ 4 ♀ (Fox).

New Jersey: Lakehurst, May, 2 ♂ 3 ♀; Midwood, 1 ♂ 1 ♀.

Pennsylvania: President, July, 1 ♂ (Palmer).

West Virginia: Buckhannon, May, 1 ♂ (E. Keyes).

Maryland: Plummer's island, May, 1 ♂ (C. R. Shoemaker).

District of Columbia: May, 7 ♂ 3 ♀ (Fox), July, 3 ♀ (Fox), Sept., 2 ♂ 2 ♀ (Fox).

Virginia: East Falls Church, June, 2 ♀ (Weld); Buckingham county, Aug., 2 ♂, (W. T. Davis)

North Carolina: Raleigh, June, 1 ♂, Apr., 1 ♂ (from stomach of *Bufo americanus* (C. S. Brimley).

Georgia: Okefinokee swamp, June, 8 ♂ 4 ♀ (Crosby); Lake Seagrove, Charlton county, June, 1 ♀ (M. D. Pirnie); Thunderbolt, June, 2 ♂ 4 ♀ (Crosby); Clayton, May, 3 ♂.

Mississippi: Ocean Springs, Jan., 4 ♂ 20 ♀ (Comstock); Trimcane, June, 1 ♂ (Herrick); Agricultural College, Mar., many ♂ (Comstock), Oct., 1 ♀ (Bailey); Oxford, June, 2 ♀ (R. H. Fulton).

Louisiana: Baton Rouge, Mar., 3 ♂ 2 ♀ (Comstock), 1 ♂ 3 ♀ (Rosewell), May, 2 ♂ 1 ♀ (Gilbeau); Chastine, Mar., 1 ♂ 7 ♀, Apr., 1 ♂ 10 ♀, May, 1 ♂ 2 ♀.

Florida: Pablo Beach, June, 1 ♀; Lake Lucy, June, 1 ♀; Lake Kissimmee, Feb.-Mar., 2 ♀ (in stomach of *Bufo terrestris*) (E. A. Mearns); Micanopy, May, 1 ♀ (Hubbell). Nov., 1 ♀ (Hubbell); Gainesville, Aug., 1 ♀ (Bradley); Rock Bluff, April, 1 ♂ 4 ♀ (Crosby); Lake Jackson, April, 2 ♀ (Crosby).

Texas: Austin, Mar., 2 ♂ 7 ♀ (Comstock).

Ohio: Urbana, July, 7 ♂ 18 ♀ (Nelson), Aug., 6 ♂ 5 ♀ (Nelson); Delaware, Aug., 6 ♂ 7 ♀ (Nelson); Gambier, Aug., 2 ♂ 5 ♀ (Nelson).

Kentucky: Clifton, June, 2 ♀ (Funkhouser); Quicksand, June, 1 ♂ 2 ♀ (Bishop and Crosby).

Tennessee: Knoxville, 2 ♂ 2 ♀ (Cartwright); Lookout Mt., June, 1 ♂ (Fox).

Michigan: Douglas lake, July–Aug., many ♂ ♀ (Matheson).

Indiana: Vowter park, June, 1 ♂ 1 ♀.

Illinois: Belleville, Aug., 3 ♂; Danville, Oct., 1 ♀ (Smith); Urbana, June, 1 ♀ (Smith), July, 2 ♀ (Smith); Brownfield, Aug., 1 ♀ (Smith); Salts, May, 1 ♀, June, 2 ♂ 4 ♀, July, 12 ♂ 14 ♀, Aug., 2 ♂ 4 ♀ (Smith); Champaign, 13 ♂ 14 ♀ (Martha Shackleford).

Minnesota: Minneapolis, June, 1 ♀ (Fletcher), July, 1 ♂ (Fletcher).

Wisconsin: Aug., 5 ♀ (Buis); Oconomowoc, June, 2 ♂ 9 ♀.

North Dakota: Fargo, June, 1 ♀ (R. L. Webster).

Kansas: Wathena, Aug., 1 ♂ 2 ♀; Manhattan, June, many ♂ ♀ (R. C. Smith).

Nebraska: Lincoln, June, 4 ♂ 11 ♀ (Pickwell), July, 1 ♂ 2 ♀ (Pickwell); Meadow, May, 1 ♀ imm. (Pickwell); Murdock, June, 1 ♀ imm. (Pickwell); Enderslake, Aug., 5 ♂ 7 ♀ (Pickwell).

Missouri: Columbia, 4 ♂ 5 ♀, May, 7 ♂ 7 ♀; June, 4 ♂ 10 ♀ (Crosby); July, 4 ♂ 5 ♀, Oct., 2 ♀ (Hayhurst); Mountain Grove, Aug., 1 ♂ 4 ♀; Hunter, Aug., 3 ♂ 2 ♀ (Crosby); Cassville, Oct., 2 ♀ (Crosby); Poplar Bluff, Aug., 3 ♀ (Crosby); Osceola, Aug., 1 ♂ (Crosby); Creve Coeur lake, Aug., 1 ♂ 1 ♀ (Crosby).

Oklahoma: Kingfisher, Oct., 1 ♀.

Montana: Bozeman, July, 3 ♂; Wilder, July, 1 ♀ (from stomach of *Bufo woodhousii*) (M. A. Hanna).

Colorado: Pingree park, Aug., 7 ♂ 8 ♀ (Crosby); Estes park, Aug., 4 ♂ 14 ♀ (Claassen); Platte canon, Sept., 1 ♂ 3 ♀ (Oslar).

Utah: Summit county, Aug., 1 ♂; Great Salt lake, June, 1 ♀ (Needham).

Wyoming: Fort Russel, June, 2 ♂ 10 ♀.

California: Palm canon, Dec., 1 ♂; Laguna, June, 1 ♂ 2 ♀; San Miguel, 1 ♂ 1 ♀ (Oslar); Berkeley, Aug., 1 ♂ (Dietrich); Northfork, May, 4 ♂ 2 ♀ (Dietrich); Harden's lake, Tuolumne county, 10 ♂ 8 ♀ (alt. 7575 feet); Pacific Grove, Oct., 1 ♂ 1 ♀ (Bradley).

Washington: Paradise Camp, Mt Rainier, Aug., 1 ♂ (Crosby); Mt Constitution, Orcas island, July, 1 ♂, 1 ♀, 2200 foot elevation (Worley)

Nova Scotia: Truro, July, 4 ♂ 18 ♀; West river, July, 3 ♂ 5 ♀.

Ontario: Point-au-Baril, Aug., 1 ♂ (L. Giovannoli); Sundford, June, 2 ♂ 10 ♀.

Alaska: Unuk river, lat. 56° 16′ N. Long. 130° 40′ W., 1 ♂ 1 ♀ (Prof. Leland).

Mexico: Lake Chapala, State of Salisco, 2 ♂ 2 ♀ (L. H. Weld).

Panama: Gorgona, March, 1 ♀ (from stomach of *Bufo marinus*) (Meek & Hildebrand).

This species has also been reported by Bryant (1908) from Maine to Connecticut. By Emerton (1884) from White Mountains to Connecticut. By Emerton (1912) from New Hampshire: Lake Winnepesaukee. By Banks (1895) from near Sea Cliff, Long Island. By Keyserling (1865) from Maryland: Baltimore. By Banks (1911) from North Carolina: Morganton, Pineola, Black Mountain, Linville, Durham, Murphy, Blowing Rock and Swannanoa Valley. By Banks (1900) from Alabama: Auburn and Opelika. By Banks (1897) from Northern Louisiana. By Barrows (1918) from Ohio: Columbus, June, Guernsey county, June, Rockridge, May, and Buckeye Lake, June. By Banks (1906) from Indiana: Tippecanoe lake, June, Hammond, May, June, July, Arlington, June, Wyandotte, June, Mitchell, April (Young), Grand Chain, June, Attica, June, Vawter park, June, Pine Lake county, May, Wilders, July, and Greencastle. By Banks (1895) from Colorado: Fort Collins, Steamboat Springs, Elk river and Mount Richtophen. By Cockerell (1911) from Colorado: Boulder. By Banks (1901) from New Mexico: Las Cruces, Ruidoso. By Banks (1904) from California: Laundry Farm, Alameda county, April (Fuchs); St Helena, Napa county, July (Fuchs); Downierville, Sierra county, Aug. (Fuchs); Los Angeles (Davidson); Palo Alto (Doane); Mount Shasta. By Moles (1915) from California: Lagana. By Strand (1908) from California: Yosemite Valley, June. By Emerton (1919) from Canada: Truro, N. S. and Aweme, Manitoba. By Banks (1916) from British Columbia: Kaslo, June, July, Kaslo creek, June (Currie), and Bear lake, July (Currie). By Banks (1900) from Alaska: Kukak bay, Kadiak, July, Yakutat, June, Popof island, Metlakahtla, June, and Sitka. By Banks (1901) from Porto Rico: Utado, Jan.

This is a dainty and graceful little spider that builds its web between the tops of tall grasses in fields often away from water. I found it to be very common in an oat field just before it was cut. It seems to be about as common as *T. extensa* and is widely distributed in North America. In the Cornell University collection there are specimens from over half the states and Mexico and southern Canada, and it is reported from Alaska and Porto Rico by Banks.

## **Tetragnatha limnocharis** n. sp.

Plate 3; figures 32–35

*Male.* Total length (exclusive of chelicerae) 6.5 mm; cephalothorax 2 mm long, 1.5 mm wide; abdomen 4.5 mm long, 0.8 mm wide; mandibles 2 mm: first leg, femur 7 mm, patella 1 mm, tibia 8 mm, metatarsus 8.5 mm; tarsus 2 mm, palpus, femur 1.9 mm, patella 0.4 mm, tibia 0.8 mm.

Cephalothorax, sternum, mandibles and legs light yellow free from markings. The mandibles are well developed, as long as the cephalothorax. The upper furrow has seven teeth, a small tooth at the base of the fang, a long prominent tooth two-thirds of distance from base to apex, a small blunt tooth just cephalad of the large one and four more evenly spaced and diminishing in size toward the base. The lower furrow has two strong teeth near base of the fang (the first slightly larger than the second) which are contiguous at the base but the tips diverge. Caudad of these two teeth are eight very small teeth. Both rows of eyes are recurved, but the anterior row is more strongly so than the posterior, bringing the lateral eyes of each side closer together than the median. The anterior median are slightly closer together than the posterior median. The posterior eyes are equal in size and equally spaced from each other, and are the largest of them all. The anterior lateral are the smallest. Legs spined.

The abdomen is slender and almost cylindrical. The ground color is light gray. Thickly dotted over this are many small pearly white spots. The venter has a narrow longitudinal dull white line.

*Female.* Total length (exclusive of chelicerae) 7.5 mm; cephalothorax 3 mm long, 1.5 mm wide; abdomen 5 mm long, 1.5 mm wide; mandibles 2.5 mm; first leg, femur 8 mm, patella 1 mm, tibia 8 mm, metatarsus 9 mm, tarsus 1.9 mm.

Cephalothorax, sternum, mandibles and legs light yellow free from markings. Mandibles more than half the length of the cephalothorax. The upper edge of the furrow has a thick, blunt tooth near the apex and after a wide interval six smaller teeth diminishing in size toward the base. The lower edge has a tooth near the apex (smaller than that at the apex of the upper row) and after an interval, half the length of that above, nine teeth closely spaced. The fang is evenly curved and has a tooth on the outer side near its base. Eyes as in the male. Legs spined.

The abdomen is somewhat thickened at the base which is not notched. It is marked as in the male.

This species I found included with *T. elongata* which it resembles somewhat, but the characters given will distinguish it, especially the dentition of the mandibles, the smaller size, and the silvery abdomen.

Type locality: Mixons Hammock, Okefinokee swamp, Georgia, 1 ♂ 1 ♀, June (Crosby). Also 3 ♂ from Billy's island, Okefinokee swamp, Georgia, June. Types in the Cornell University collection.

### **Tetragnatha orizaba** Banks

Plate 3, figures 36–39

*Eugnatha orizaba* Banks. Calif. Acad. Sci. Proc. 1:248, pl. 15, fig. 16. 1898
*Eugnatha orizaba* Petrunkevitch. Am. Mus. Nat. Hist. Bul. 29:339. 1911

*Male.* Total length (exclusive of chelicerae) 5 mm; cephalothorax 1.5 mm long, 1 mm wide; abdomen 3.5 mm long, 0.8 mm wide; mandibles 1 mm; first leg, femur 4 mm, patella 0.7 mm, tibia 4 mm, metatarsus 4 mm, tarsus 1.2 mm; palpus, femur 1 mm, patella, tibia and bulb together 1 mm.

Cephalothorax, legs, mandibles and palpi light yellowish unmarked except for faint duskiness along the edge of the cephalothorax. The posterior row of eyes is more recurved than the anterior row, making the lateral eyes of each side slightly farther apart than the median. The posterior eyes are the largest, equidistant from each other and equal in size. The anterior lateral are the smallest and are a little farther removed from the anterior median than these are from each other. The mandibles are a little more than half the length of the cephalothorax, the upper row has five teeth, the second from the apex much enlarged. The lower row has five teeth, the apical tooth a little larger than the others. The dorsal spur on the mandibles is neither pointed nor bifid, but is laterally compressed at the tip. The legs have a few short spines. The sternum is dusky with a median longitudinal area light yellowish.

The abdomen is long and slender, with a very slight taper from base to apex. The base is not notched. The abdomen above is silvery with a gray folium and reticulations. The lower half of the abdomen is dark, divided by two narrow light lines into three dark bands.

*Female.* Total length (exclusive of chelicerae) 5.9 mm; cephalothorax 2 mm long, 1 mm wide; abdomen 4 mm long, 0.8 mm wide; mandibles 1 mm long; first leg, femur 4 mm, patella 0.8 mm, tibia 4 mm, metatarsus 3.5 mm, tarsus 1.1 mm.

Cephalothorax, legs, sternum and eyes as in the male. The mandibles are half as long as the cephalothorax and have five teeth in each row. The fang is evenly curved and has no tooth at the base on the outer side.

Abdomen as in the male except that the base has a shallow notch.

Cuba: Cerro Cabras (near P. d. R.) Sept., 1 ♂ 1 ♀; Pinar Rio, Sept., 1 ♀; Cabanas, Sept., 2 ♀.

**Banks described it from Mount Orizaba, Mexico.**

## **Tetragnatha pallescens** Cambridge

Plate 3, figures 40–43

*Tetragnatha pallida* Banks. Acad. Nat. Sci. Phila. Proc. 1892, p. 51, pl. 5, figs. 88, 88*a*

*Eugnatha pallida* Banks. N. Y. Ent. Soc. Jour. 1:132. 1893

*Eugnatha pallida* McCook. American Spiders, 3:265, pl. 25, figs. 10, 11. 1893

*Eugnatha pallida* Banks. Calif. Acad. Sci. Proc. (3) 1:248. 1898

*Eugnatha pallida* Banks. Acad. Nat. Sci. Phila. Proc. 1901, p. 581

*Eugnatha pallida* Banks. Acad. Nat. Sci. Phila. Proc. 1904, p. 132

*Tetragnatha pallescens* Cambridge. Biol. Cent. Americana, 2:436. 1905 (pallida preoccupied by Cambridge 1889)

*Eugnatha pallida* Banks. Secretary of Agr. of Cuba. Second Rep't 1909, p. 164

*Tetragnatha vermiformis* Emerton. Conn. Acad. Sci. Trans. 14:201, pl. 5, figs. 5, 5*a*. 1909

*Eugnatha pallidula* Banks. U. S. Nat. Mus. Bul. 72:36. 1910

*Eugnatha pallescens.* Petrunkevitch. Am. Mus. Nat. Hist. Bul. 29:340. 1911

*Tetragnatha pallidula* Comstock. Spider Book, p. 415, fig. 423*b*. 1912

*Eugnatha pallescens* Lutz. N. Y. Acad. Sci., Ann. 26:88. 1915

*Tetragnatha pallida* Banks. Acad. Nat. Sci. Phila. Proc. 1916, p. 78

*Tetragnatha pallida* Barrows. Ohio Jour. Sci. 18:307. 1918.

*Male.* Total length (exclusive of chelicerae) 8 mm; cephalothorax 2.6 mm long, 1 mm wide; abdomen 5 mm long, 0.8 mm wide; mandibles 2.5 mm; first leg, femur 6.8 mm, patella 1 mm, tibia 5 mm, metatarsus 7.9 mm, tarsus 1.7 mm; palpus, femur 1.5 mm, patella 0.5 mm, tibia 0.9 mm.

Cephalothorax very light reddish brown unmarked, of even height throughout, widest in the center, constricted where thoracic furrows reach the margin. Chelicerae about as long as cephalothorax, the upper margin with eight teeth, the outermost, at the base of the fang, the largest, then, after an interval, another tooth, and after a longer interval six teeth diminishing in size toward the base. The lower margin has seven teeth, the outermost, near the fang, the largest, then two minute teeth, then four small teeth. The long tooth on the upper margin of other males is lacking. The dorsal spur is not bifid, but has a slight tooth below the apex. Fang slightly sinuate.

The anterior row of eyes is straight, the posterior row recurved, thus bringing the median eyes of each side nearer together than the lateral eyes. Anterior median closer together than posterior median. Anterior lateral smaller than the other eyes which are equal in size. Sternum of same color as dorsum, somewhat darker along the edges. Labium dark.

The abdomen is long and narrow, tapering from base to apex. Base notched. Marked somewhat as *T. laboriosa*, but darker. On

the venter there is an indication of a dark longitudinal band, but it is not well defined.

*Female*. Total length (exclusive of chelicerae) 10.5 mm; cephalothorax 2.5 mm long, 1.5 mm wide; abdomen 7.2 mm long, 0.8 mm wide near base; mandibles 2 mm; first leg, femur 6 mm, patella 1 mm, tibia 6.9 mm, metatarsus 7 mm, tarsus 1.2 mm.

Cephalothorax of even height throughout, widest in the middle, constricted where thoracic furrows reach the margin, light yellowish brown with diffused dusky lines from base to posterior eyes. Eyes as in the male. Chelicerae rather long, shorter than the cephalothorax, upper margin with six teeth, the outermost, at base of fang, the largest, then, after an interval, five more teeth diminishing in size toward base. Lower margin has seven teeth, one near the fang, a short interval, another tooth, another interval, and then a row of five teeth. Fang is evenly curved, with no tooth near the base. The sternum has a dusky border. The endites scarcely or just reach to the tip of the fangs when folded.

The abdomen is long, somewhat swollen near the base, thence tapering to the apex. The base is notched. Marked similarly to *T. laboriosa* but duller and venter is evenly dark throughout.

New York: Cinnamon lake, Schuyler county, July, 1 ♀, Sept., 1 ♂; Ithaca, May, 1 ♂ imm.; Labrador pond, Cortland county, June, 1 ♀ (Crosby); Watervliet reservoir, Albany county, 1 ♀ (M. D. Leonard); Voorheesville, June, 2 ♀ (Bishop) Rensselaer, Sept., 1 ♂ (Schoonmaker); Burden lake, Rensselaer county, 2 ♀ (Schoonmaker); Cold Spring Harbor, July, 1 ♀ (M. Gordon).

Maine: Portland, Sept., 2 ♀ (Britcher).

Maryland: Chestertown, 1 ♂ (F. Hartman).

District of Columbia, Oct., 2 ♂ (Fox).

N. Carolina: Kure Beach, Fort Fisher, Oct., 1 ♀.

Georgia: Okefinokee swamp, June, 2 ♂ (Crosby); Spring creek, Seminole county, April, 1 ♂ 1 ♀ (Crosby).

Florida: Lakeland, Aug., 1 ♂ 1 ♀; Pablo beach, June, 1 ♂; Dead lake, Apr., 1 ♂ 5 ♀ (Crosby); Lake Jackson, Apr., 3 ♀ (Crosby); Dunedin, Dec., 1 ♂ 1 ♀ (W. S. Blatchley); Manatee county, Jan., 2 ♂; Palm Beach, April, 2 ♀ (Fletcher); Apalachicola, Apr., 2 ♂ 3 ♀ (Crosby); Tampa, July, 1 ♀ (Stone).

Louisiana: 1 ♀ (Gilbeau); Jennings 2 ♀.

Texas: Victoria, July, 1 ♂ (J. D. Mitchell).

Missouri: Mountain Grove, Aug., 1 ♂ (Crosby); Columbia, July, 1 ♂ 7 ♀ (Crosby); Creve Coeur lake, Aug., 1 ♂ 2 ♀ (Crosby).

Minnesota: Minneapolis, July, 1 ♀ (Fletcher).

Porto Rico: Toa-Baja, 4 ♂ 3 ♀ 6 imm. (Garb).

This species has also been reported by Emerton (1909) from Cambridge, Mass., Sept. ♂ ♀. By Barrows (1918) from Buckeye lake, Ohio, July. By Banks (1901) from New Mexico: Beulah, 1 ♂. By Banks (1898) from Tepic, Baja California, Oct., and by Banks (1909) from Cuba: Santiago de las Vegas, and Havana.

This seems to be an uncommon but widely distributed species. Specimens in our collection are few and take in the area from New York to Florida and Porto Rico, west to Minnesota and Missouri. Banks reports it from Lower California. A very closely related species (*Eugnatha gracilis* Cambridge 1889) inhabits Mexico, West Indies and Central America.

### Tetragnatha pinea n. n.

Plate 2, figures 21–24

*Tetragnatha pinicola* Emerton. Conn. Acad. Sci. Trans. 20:139, pl. 1, fig. 7, 7*a*. 1915. Preoccupied by L. Koch, 1870

*Male*. Total length (exclusive of mandibles) 5.6 mm; cephalothorax 2 mm long, 1.1 mm wide; abdomen 4 mm long, 0.9 mm wide; mandibles 1.4 mm; first leg, femur, 5 mm; patella 1 mm; tibia 6 mm, metatarsus 6.1 mm, tarsus 1 mm; palpus, femur 1.1 mm, patella 0.2 mm, tibia 0.5 mm.

Cephalothorax of even height throughout its length, constricted where thoracic furrows reach margin, very light yellow without markings. Chelicerae more than half as long as the cephalothorax. The upper margin of the furrow has nine teeth, a large prominent tooth two-thirds of distance from base to apex, two small teeth between this and the apex, and six between it and the base diminishing in size toward the base; on the lower margin there are seven small teeth. The dorsal spur is shallowly bifid. Fang evenly curved. The legs are green and have very long, slender spines, those on tibia 1 being four to six times as long as the thickness of the tibia. The eyes are like those of *T. laboriosa*. Sternum is colored as the cephalothorax and without markings.

The abdomen is notched at the base and overhangs the cephalothorax. Above it is silvery with a greenish tinge and a blotch of red at the base. On the under side it is silvery.

*Female*. The female closely resembles the female of *T. laboriosa*. It is easily distinguished, however, by being light green in color, the abdomen and legs especially so. The abdomen usually has red on it either confined to the base of the dorsum or extended in a broad

band the full length of the abdomen. The female also has very long spines, those on tibia I being three to six times the thickness of the tibia.

New York: Long pond, Suffolk county, Sept., 1 ♂ immature, 10 ♀ immature (Chapman and Boyce) on pines.

North Carolina: Lake Waccamaw, Oct., 1 ♀ immature (Bishop and Crosby).

Florida: Rock Bluff, April 4, 1927, 1 ♂ (Crosby).

Emerton (1915) records it from Nantucket and Martha's Vineyard, Mass. Mr Emerton was kind enough to lend me 3 ♀ from Chatham, Mass., taken in July and 1 ♂ 5 ♀ imm., from Hyannis, Mass., Sept., on pines.

### **Tetragnatha seneca** n. sp.

Plate 4, figures 44–48

*Male.* Total length (exclusive of chelicerae) 6 mm; cephalothorax 2.1 mm long, 1.8 mm wide; abdomen 4 mm long, 1.7 mm wide; mandibles 2.1 mm long; first leg, femur 6 mm, patella 1 mm, tibia 6 mm, metatarsus 6 mm, tarsus 1.4 mm; palpus, femur 2 mm, patella 0.3 mm, tibia 0.8 mm.

The cephalothorax is of even height throughout, light reddish brown with sooty markings along the edges and the furrows. The furrows are well defined. Chelicerae are well developed, about as long as the cephalothorax, the upper margin with seven teeth arranged as follows: The largest near the apex and set lower than the other teeth, near it a small tooth, then after an interval five more evenly spaced and diminishing in size toward the base. In some specimens there are two to four minute teeth at the base of the upper row. The lower margin has seven teeth, the largest near the fang, a smaller one near it, and after an interval five more. The lower row of teeth does not extend so near to the base of the mandible as does the upper row. None of the teeth are large or prominent. The spur on the dorsal side of the mandible is not bifid and there is no tooth on it as in *T. pallescens*, but the tip appears to be beveled at a very acute angle. The fang is very slightly sinuate.

Both rows of eyes are recurved but the anterior row more strongly than the posterior which is almost straight. The lateral eyes of each side are placed on a small prominence and are almost contiguous. The anterior and posterior median are about one diameter of the posterior median apart. The posterior eyes are equidistant from each other, but in the anterior row the distance from median to lateral is twice the distance between the two median. The anterior median

are closer together than the posterior median. The posterior eyes are the largest and equal in size, and the anterior lateral are the smallest.

The abdomen is widest at the middle, thence tapering to the broadly rounded apex. The base is not notched. It is grayish with small silver spots and with fine black lines on the sides. The venter has a median longitudinal grayish band with a lighter band on each side of it.

*Female.* Total length (exclusive of chelicerae) 8 mm; cephalothorax 2.5 mm long, 2 mm wide; abdomen 6 mm long, 3.5 mm wide; mandibles 1.2 mm; first leg, femur 5 mm, patella 1 mm, tibia 5 mm, metatarsus 5 mm, tarsus 1.5 mm.

The cephalothorax as in the male. The chelicerae are about half as long as the cephalothorax, the upper margin with seven and the lower margin with six teeth, all nearly evenly spaced. The fang has no tooth on the outer side at the base, but there is a minute tooth on the inner side opposite the second tooth of the lower row. The fang has a sharp bend at the base, and thence is more broadly curved.

The abdomen is wide and high in the middle in typical specimens, but in other specimens this is not seen. It is light gray with a darker folium on the dorsum and silver spots. The sides are mottled with silver gray, and brown. The venter has a broad gray longitudinal band with a lighter band on each side of it. There are two white spots on either side of the abdomen near the spinnerets.

The males of this species superficially resemble *elongata* but are easily distinguished from all the other species having the lateral eyes closer together than the median by lacking the long prominent tooth in the upper row and the bifid spur. The female closely resembles *extensa* but lacks the tooth on the outer side of the fang at the base and has a small one on the inner side, while the fang itself is not evenly curved as in *extensa*. The specimens of *seneca* in the Cornell University collection were all labelled *elongata* or *extensa*. Professor Crosby tells me that the Lakeside Park specimens were taken by sweeping lily pads and other vegetation on the surface of a drowned stream flowing into Lake Erie.

Type locality: Lodi landing, Seneca lake, New York, July, 1 ♂ 1 ♀ (deposited in the Cornell University collection).

New York: Ithaca, 1 ♂ 7 ♀ ; Lakeside park, Orleans county, (Crosby), July, 2 ♂ ; Lodi landing, (Seneca lake) July, 1 ♂ 1 ♀ ; Ashokan, Ulster county, Aug., 1 ♀ (Treadwell); Rockaway Beach, Queens county, Sept., 1 ♂ 1 ♀ (Pike); Long pond, Suffolk county, Sept., 1 ♂ 5 ♀ (Boyce and Chapman).

Massachusetts: Wood's Hole, Sept., 1 ♀.
Maryland: Chestertown, May, 2 ♂ 3 ♀ (F. Hartman).
District of Columbia: Sept., 2 ♀ (Fox).
N. Carolina: Lake Waccamaw, Oct., 1 ♂.
Florida: Miami, Mar., 1 ♀ (Comstock); Lake Kissimmee, Feb.-Mar., 1 ♂ 1 ♀ (from stomach of *Bufo terrestris*) (E. A. Mearns); Gainesville, March, 1 ♂ (Hubbell), Oct., 2 ♀ (Leonard), Newman's lake, Feb., 1 ♂ (Miller); Belle Glade, Lake Okeechobee, July, 2 ♂ 2 ♀ (M. D. Leonard); Dead lake, April, 5 ♂ 6 ♀ (Crosby).
Louisiana: Baton Rouge, March, 2 ♂ 4 ♀ (Comstock); A. & M. College, 1 ♀; Jennings, 1 ♀.

### **Tetragnatha straminea** Emerton

Plate 4, figures 49–54

*Tetragnatha straminea* Emerton. Conn. Acad. Sci. Trans. 6:335, pl. 39, figs. 15, 17, 20, 21. 1884
*Tetragnatha straminea* Cambridge. Biol. Centr. Amer. 1:XIV. 1889
*Eugnatha straminea* Marx. U. S. Nat. Mus. Proc. 12:553. 1889
*Tetragnatha straminea* Banks. Acad. Nat. Sci. Phila. Proc. 1892, p. 51
*Eugnatha straminea* Simon. Hist. Nat. Ar. 1: 721. 1892
*Eugnatha straminea* Banks. N. Y. Ent. Soc. Jour. 1:132. 1893
*Tetragnatha straminea* Emerton. Common Spiders, p. 204, figs. 464, 468. 1902
**Eugnatha straminea* Britcher. Onondaga Acad Sci. Proc. 1:123–30. 1903
*Eugnatha straminea* Banks. Indiana Dep't Geol. & Nat. Res. Rep't 31:739. 1906
*Tetragnatha straminea* Bryant. Bost. Soc. Nat. Hist. Occ. Papers, 7:47. 1908
*Eugnatha straminea* Banks. U. S. Nat. Mus. Bul. 72:37. 1910
*Eugnatha straminea* Banks. Acad. Nat. Sci. Phila. Proc. 63:449. 1911
*Eugnatha straminea* Petrunkevitch. Am. Mus. Nat. Hist. Bul. 29:340. 1911
*Tetragnatha straminea* Comstock. Spider Book, p. 414, figs. 423*a*, 427. 1912
*Tetragnatha straminea* Banks. Acad. Nat. Sci. Phila. Proc. 68:78. 1916
*Eugnatha straminea* Barrows. Ohio Jour. Sci. 18:307. 1918

*Male.* Total length (exclusive of chelicerae) 6.5 mm; cephalothorax 2.2 mm long, 1.1 mm wide; abdomen 0.9 mm wide, 4.4 mm long; chelicerae 1.3 mm long; first leg, femur 6 mm, patella 1 mm, tibia 7 mm, metatarsus 7 mm, tarsus 1.9 mm; palpus, femur 1.5 mm, patella 0.4 mm, tibia 0.8 mm.

Cephalothorax of even height throughout, widest at the center, constricted where thoracic furrows reach the margin, with two faint dusky parallel lines from base to posterior eyes. The anterior row of eyes is procurved, the posterior row straight or slightly recurved, thus bringing the median eyes closer together than the lateral of each side. The anterior median are slightly closer together than the

posterior median. The anterior lateral are the smallest, the posterior eyes the largest. Chelicerae little more than half as long as cephalothorax, the upper margin with six teeth, a large tooth two-thirds of distance from base to apex, three small teeth between this and the base, a blunt tooth at base of fang and another between this and the large tooth. The lower margin has eight teeth, the largest at the base of the fang, the rest small. Fang evenly curved. The dorsal spur is bifid. Endites extending past the tips of the fangs when closed. Sternum with a dusky border, the middle the same color as the dorsum. Labium is dark.

The abdomen has a slight taper from base to apex and shallowly notched at the base. Above it is marked as in *T. laboriosa;* the venter has an indistinct dark longitudinal band.

*Female.* Total length (exclusive of chelicerae) 8 mm; cephalothorax 2.2 mm long, 1.2 mm wide; abdomen 6 mm long, 1.5 mm wide; chelicerae 1.5 mm; first leg, femur 5 mm; patella 1 mm, tibia 5.9 mm, metatarsus 3.5 mm, tarsus 1 mm.

Cephalothorax highest at the eyes, broadest at the center, constricted where the thoracic furrows reach the margin, reddish yellow with faint duskiness along the center. Eyes as in the male. Chelicerae about half as long as cephalothorax, the upper row with five teeth, one near base of the fang and, after an interval, a row of four; lower margin with seven teeth, one near base of fang, and, after a shorter interval than in upper margin, six more teeth in a row. Fang evenly curved, a small blunt tooth near the base. Endites, sternum, and labium as in male.

Abdomen tapering from base to the apex which is bluntly pointed. The base is notched. The abdomen resembles that of *T. laboriosa*, but it is longer and narrower and the reticulations are much less prominent. It is often silvery white.

This species seems to be rather common, but rather restricted in distribution. Cambridge reports it from Central America. There is in Mexico and Central America a close relative of this species (*T. alba* Cambridge) which Cambridge may have confused with *T. straminea.*

New York: Trenton Falls, June, 3 ♂ 1 ♀ ; Pompey, Sept., 3 ♂ imm. 16 ♀ imm. (Britcher); Jamesville, Oct., 2 ♂ imm. 27 ♀ imm. (Britcher); Tully, Oct., 7 ♀ imm. (Britcher); Baldwinsville, Sept., 25 imm. (Britcher); Indian Reservation Spring, Sept., 5 ♀ (Britcher); Apulia, Oct., 1 ♀ (Britcher); Painted Post, Sept., 1 ♀ imm.; Interlaken, July, 1 ♀ ; Lake Keuka, June, 1 ♂ ; Enfield glen, May, 1 ♂, ♂ ♀ imm.; Ithaca, July, 2 ♂ , Oct., 17 ♀ imm., 3 ♀ ; McLean, May

many ♂ ♀; Labrador pond, May, 1 ♀ (Tarris), June, 2 ♂ 2 ♀; Thompson, May, 5 ♀ imm.; Normansville, Albany county, July, 2 ♀ (Bishop); Voorheesville, June, 1 ♂ 1 ♀ (Bishop); Tackawasick pond, June, 1 ♀ (Bishop); Rensselaer, Sept., 1 ♀ (Schoonmaker).

New Hampshire: Hollis, Aug., 1 ♀ (Fox).

District of Columbia, May, 1 ♂ 5 ♀ (Fox), July, 1 ♀ (Fox).

Mississippi: Ocean Springs, Jan., 1 ♀ (Comstock).

Alabama: Hull lake, Tuscaloosa county, July, 1 ♀ (H. H. Smith).

Florida: Belle Glade, Lake Okeechobee, July, 1 ♀ (M. D. Leonard); Sanford, Sept., 1 ♂, 1 ♀ imm. (Stone); Tampa, July, 3 ♀ (Stone).

Illinois: Belleville, Aug., 1 ♂ 1 ♀.

Michigan: Douglas lake, July (R. Matheson).

Minnesota: Fort Snelling, July, 1 ♀ (Fletcher); Minneapolis, June, 1 ♀ (Fletcher).

Nebraska: Lincoln, July, 2 ♂ 2 ♀ (G. Pickwell).

This species is also reported by Bryant (1908) from Maine: Portland; Vermont: Stowe and Essex; Massachusetts: Boston, Cambridge, and Ipswich; Connecticut: New Haven. By Banks (1911) from North Carolina: Linville and Swannanoa Valley. By Barrows (1918) from Ohio: Rockbridge, June ♂ ♀, and cedar Point ♂. By Banks (1906) from Indiana: Tippecanoe Lake, June. By Cambridge (1889) from Mexico or Central America.

### **Tetragnatha vermiformis** Emerton

Plate 4, figures 55–58

*Tetragnatha vermiformis* Emerton. Conn. Acad. Sci. Trans. 6:333, pl. 39 figs. 12, 13, 14. 1884
*Eucta vermiformis* Marx. U. S. Nat. Mus. Proc. 12:553. 1889
*Tetragnatha vermiformis* Banks. Acad. Nat. Sci. Phila. Proc. 1892, p. 51
*Eucta vermiformis* Simon. Hist. Nat. Ar. 1:722, 725. 1892
*Eugnatha vermiformis* Banks. N. Y. Ent. Soc. Jour. 1:132. 1893
*Eugnatha vermiformis* McCook. American Spiders, 3:264, pl. 25, fig. 9. 1893
*Eugnatha vermiformis* Banks. N. Y. Ent. Soc. Jour. 3:89. 1895
*Eucta vermiformis* Bryant. Bost. Soc. Nat. Hist. Paper 7:48. 1908
*Eucta vermiformis* Petrunkevitch. Amer. Mus. Nat. Hist. Bul. 29:339. 1911
*Tetragnatha vermiformis* Comstock. Spider Book, p. 414. 1912
*Tetragnatha vermiformis* Banks. Acad. Nat. Sci. Phila. Proc. 68:78. 1916
*Tetragnatha vermiformis* Emerton. Roy. Canad. Inst. Trans. 12:321. 1919

*Male.* Total length (exclusive of chelicerae) 8 mm; cephalothorax 3 mm long, 1.9 mm wide; abdomen 5 mm long, 1 mm wide; mandibles 2.1 mm; first leg, femur 6 mm, patella 1 mm, tibia 6.5 mm, metatarsus 6.5 mm, tarsus 1.7 mm; palpus, femur 1.1 mm, patella and tibia together 1 mm.

Cephalothorax highest in front, the furrows deep, light reddish. The posterior row of eyes is recurved, the anterior row procurved. The two rows of eyes are well separated from each other, the lateral on each side are almost twice as far apart as the anterior median from the posterior median. The posterior eyes are equal in size and equidistant from each other. The anterior lateral are the smallest and are twice as far from the anterior median as these are from each other. The anterior lateral eyes are each placed on small tubercles at the ventro-lateral angle of the face. The anterior median are likewise situated one on each side of a median tubercle. The chelicerae are shorter than the cephalothorax. There are five teeth arranged in a row remote from the apex on the upper margin of the furrow, a greatly enlarged and prominent tooth stands above the row, and two more somewhat smaller stand near the tip of the mandible. Of these last two, the outer tooth is thin and frail and curves forward, the inner tooth is thick and is suddenly brought to a point. On the lower margin are seven teeth, two at the base of the fang the largest, the others arranged in a row extending forward farther than the row on the upper margin. The fang is slightly sinuous and is roughened on the inner side by small uneven projections.

The abdomen is hardly twice as long as the cephalothorax. It is narrow, with but a slight taper from base to apex. The base is very shallowly notched. It is silvery with gray reticulations and no folium.

The female has not been seen by me and therefore I give no description of it.

Nebraska: Enderslake, Aug., 1 ♂ (G. Pickwell).

The male loaned me by Mr Emerton is from Wood's Hole, Mass., Aug. 1881. Emerton (1884) also reports it from Beverly and Middleton, Mass., and Miss Bryant (1908) from Beverley, Cambridge, Middleton, and Wood's Hole, Mass., and New Haven, Conn.; Banks (1895) from near Sea Cliff, Long Island, July; Emerton (1919) from Toronto, Canada.

## EXPLANATION OF PLATES

### Plate 1

Figure 1 *Tetragnatha antillana* Simon. Male. Right mandible from above

Figure 2 *Tetragnatha antillana* Simon. Female. Right mandible from above

Figure 3 *Tetragnatha antillana* Simon. Female. Tip of mandible from below

Figure 4 *Tetragnatha antillana* Simon. Male. Palpus; femur, patella and tibia

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Figure 6 *Tetragnatha caudata* Emerton. Dorsal spur on mandible of male

Figure 7 *Tetragnatha caudata* Emerton. Female. Right mandible from above

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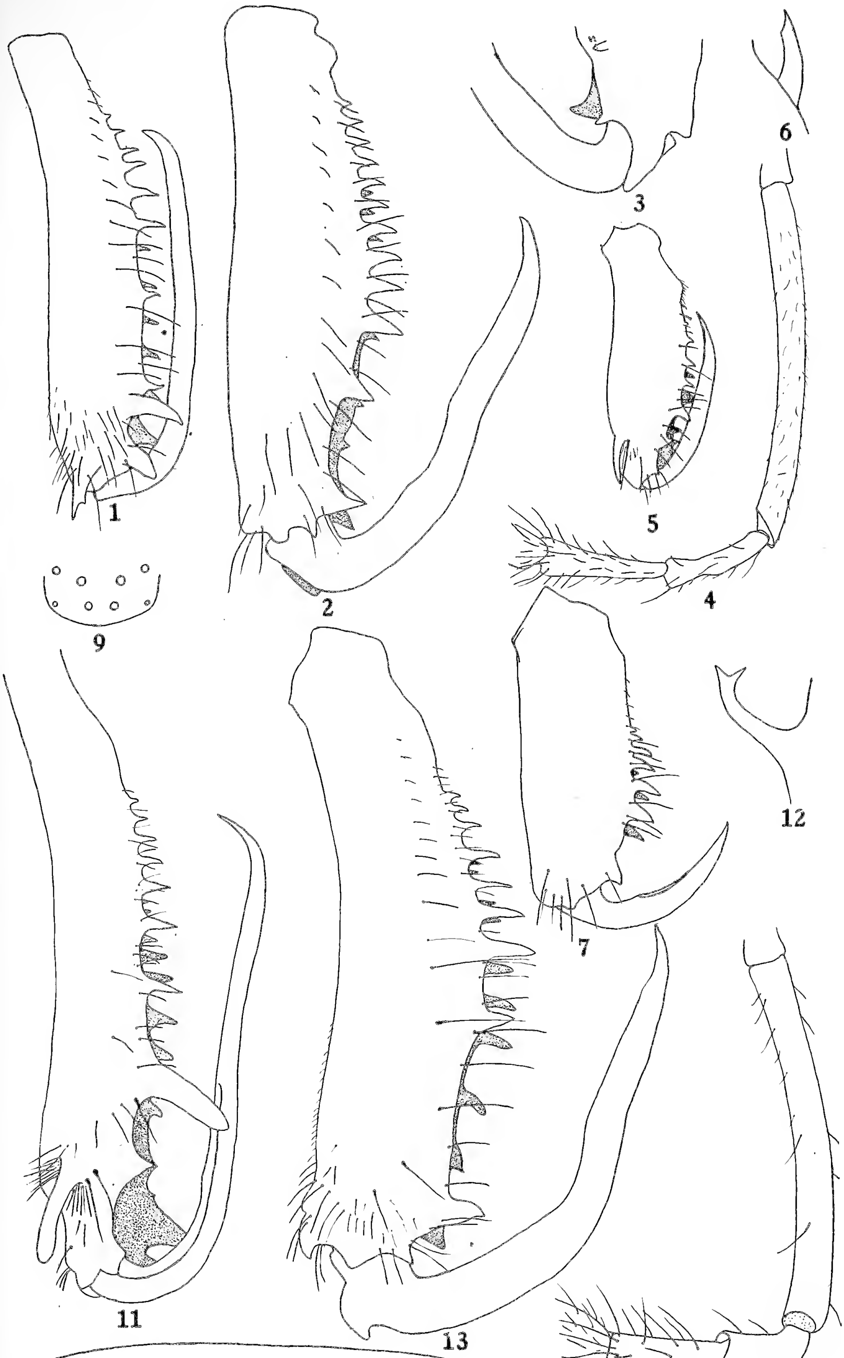
Figure 12 *Tetragnatha elongata* Walckenaer. Dorsal spur on mandible of male

Figure 13 *Tetragnatha elongata* Walckenaer. Female. Right mandible from above

Plate I



## Plate 2

Figure 14 *Tetragnatha elongata* Walckenaer. Male. Palpal organ

Figure 15 *Tetragnatha elongata* Walckenaer. Tip of conductor of male palpus

Figure 16 *Tetragnatha elongata* Walckenaer. Arrangement of eyes as seen from in front

Figure 17 *Tetragnatha extensa* Linnaeus. Male. Right mandible from above

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Figure 19 *Tetragnatha extensa* Linnaeus. Female. Right mandible from above

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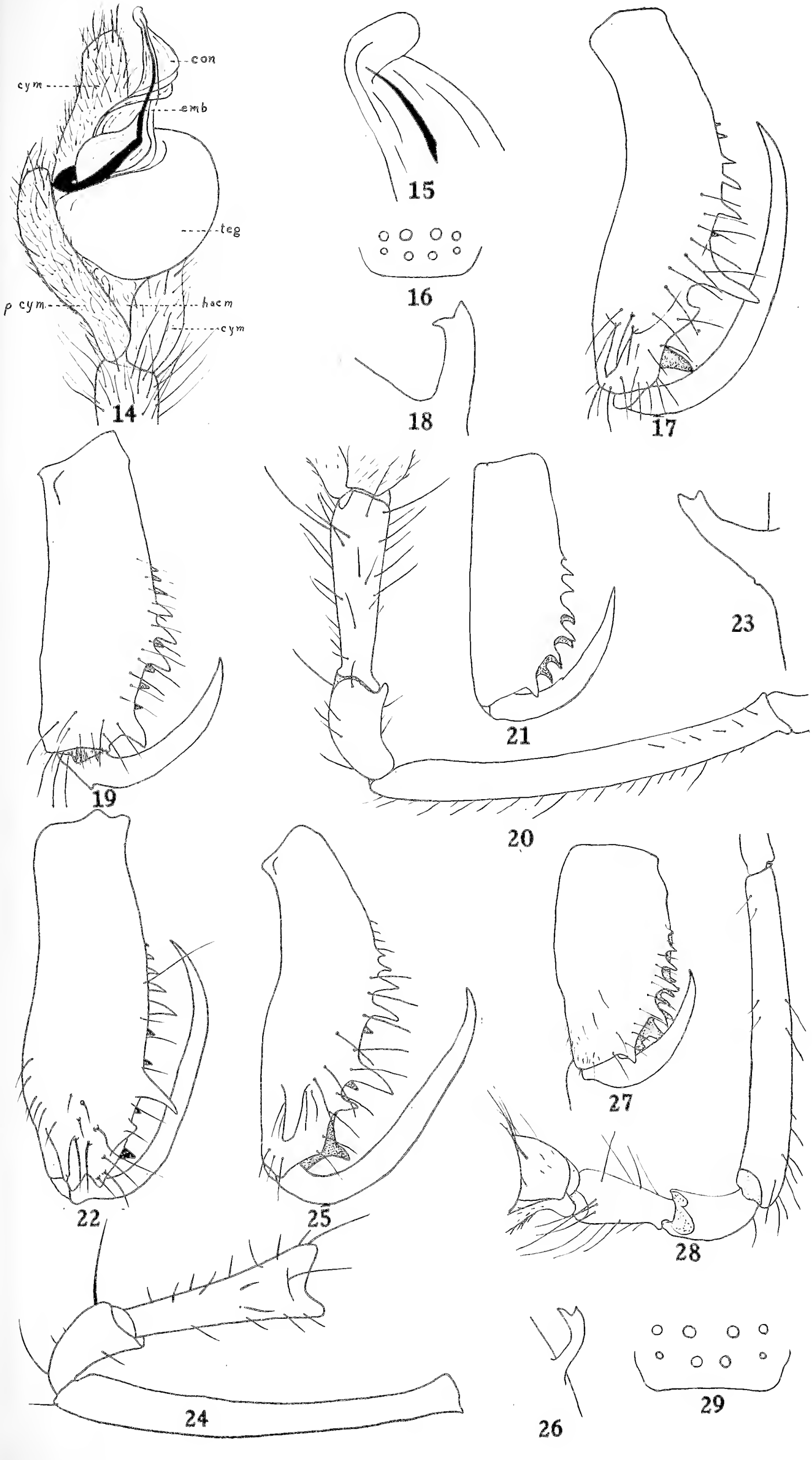
Figure 29 *Tetragnatha laboriosa* Hentz. Arrangement of eyes as seen from in front

Plate 2



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## Plate 3

Figure 30 *Tetragnatha laboriosa* Hentz. Male. Palpal organ

Figure 31 *Tetragnatha laboriosa* Hentz. Tip of conductor of male palpus

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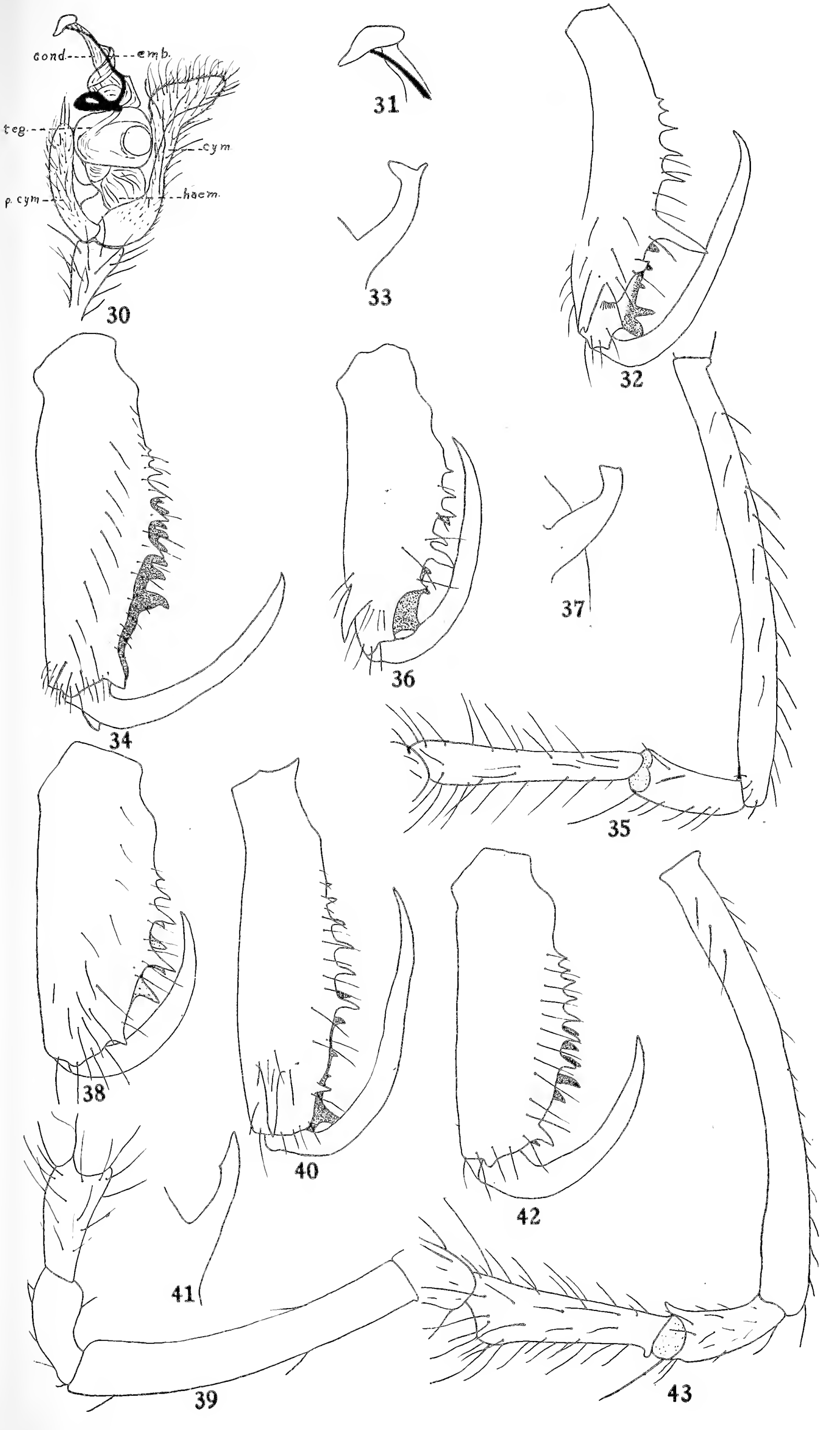
Figure 43 *Tetragnatha pallescens* Banks. Male. Palpus; femur, patella and tibia

Plate 3



## Plate 4

| | |
|---|---|
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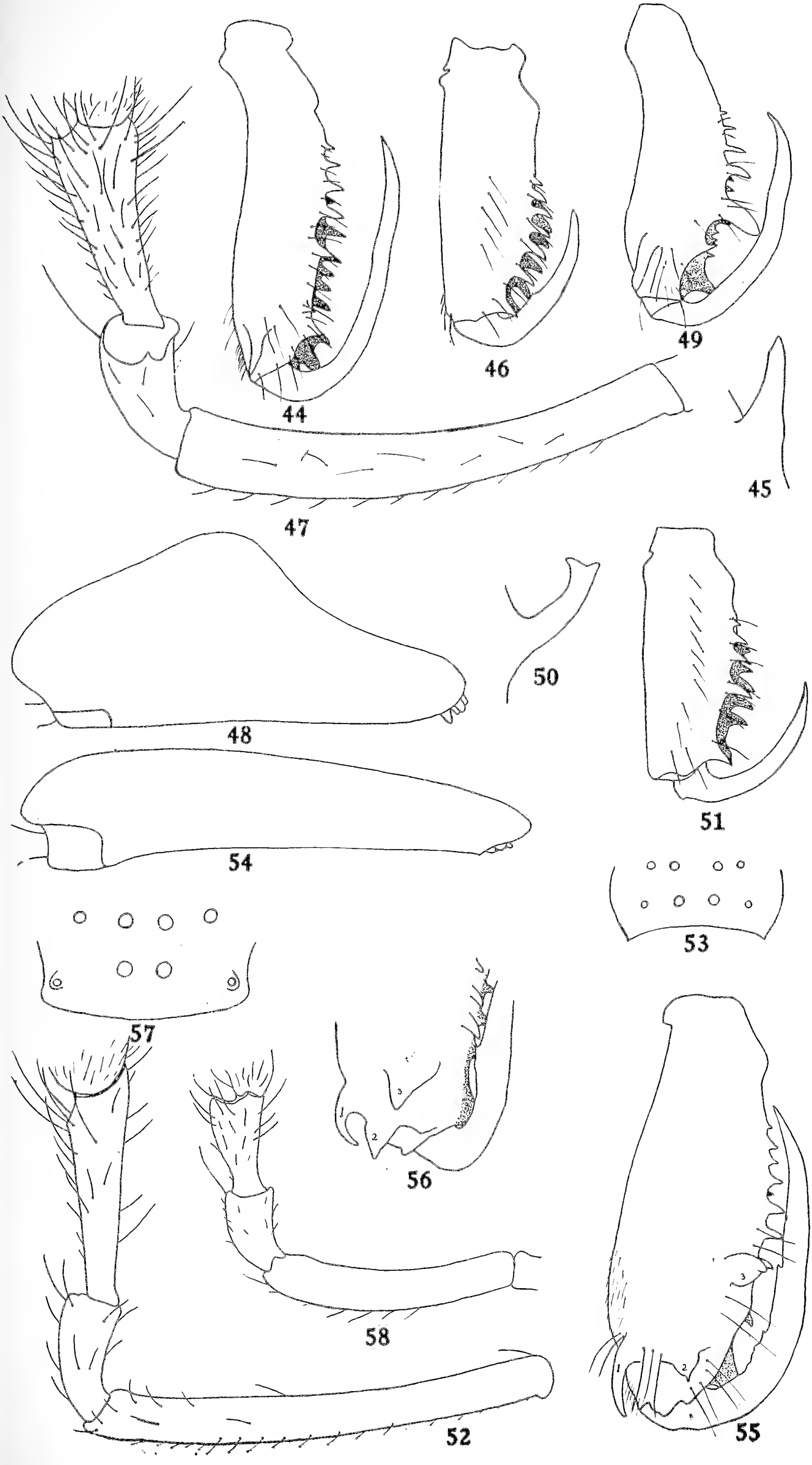
Plate 4



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# New York State Museum Bulletin

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No. 279 ALBANY, N. Y. January 1929

## New York State Museum

CHARLES C. ADAMS, *Director*



# TWENTY-SECOND REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

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ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

1929

M231r-My28-1000(6228)

*New State State Education Department*
*The State Museum, February 20, 1928*

*The Honorable Frank P. Graves,*
*President of the University and*
*Commissioner of Education*

SIR: I beg to submit herewith the report of the Director of the State Museum for the period from January 1, 1926, to June 30, 1927.

Very respectfully
CHARLES C. ADAMS
*Director*

## THE LEGAL STATUS OF THE NEW YORK STATE MUSEUM

All scientific specimens and collections, works of art, objects of historic interest and similar property appropriate to a general museum, if owned by the State and not placed in other custody by a specific law, shall constitute the State Museum. [*Education Laws,* § *54.*]

The Librarian of any library owned by the State, or the officer in charge of any state department, bureau, board, commission or other office may, with the approval of the Regents, transfer to the permanent custody of the State Library or Museum any books, papers, maps, manuscripts, specimens or other articles which, because of being duplicates or for other reasons, will in his judgment be more useful to the State in the State Library or Museum than if retained in his keeping. [*Education Law,* § *1115.*]

## THE FUNCTIONS OF THE STATE MUSEUM

"The Museum is the natural scientific center of the State government; it is the natural depository of all the material brought together by the state surveys; it is the natural custodian of all purely scientific state records; it is the natural center of the study of the resources of the State as a political unit; it must maintain its capacity for productiveness in pure scientific research—pure science has been the justification of the State Museum from the beginning of its history. * * * In brief, the distinctive sphere and scope of the State Museum corresponds with the scientific interests and welfare of the people within the geographic boundaries of the State.

The truest measure of civilization and of intelligence in the government of a state is the support of its institutions of science, for the science of our time in its truest sense is not the opinions or prejudices, the strength or weakness of its votaries, it is the sum of our knowledge of nature with its infinite applications to State welfare, to State progress and to the distribution of human happiness."—*Henry Fairfield Osborn, an address delivered at the dedication of the New York State Education Building, October 15, 1912.*

## THE FUNCTIONS OF A MUSEUM

"A museum is an institution for the preservation of those objects which best illustrate the phenomena of nature and the works of man, and the utilization of these for the increase of knowledge and for the culture and enlightenment of the people.

In addition to local accessories, the opportunity for exploration and field work are equally essential, not only because of considerations connected with the efficiency of the staff * * * but in behalf of the general welfare of the institution. Other things being equal, exploration can be carried on more advantageously by the museum than by any other institution of learning, and there is no other field or research which it can pursue to better advantage.

To aid the occasional inquirer, be he a laboring man, schoolboy, journalist, public speaker, or savant, to obtain, without cost, exact information upon any subject related to the specialties of the institution; serving thus as a "bureau of information."

A museum to be useful and reputable must be constantly engaged in aggressive work either in education or investigation, or in both.

A museum which is not aggressive in policy and constantly improving can not retain in its service a competent staff and will surely fall into decay.

A finished museum is a dead museum, and a dead museum is a useless museum."—*G. Brown Goode, formerly assistant secretary, Smithsonian Institution.*

## Museum Committee of the Board of Regents

Wm Leland Thompson, *Chairman*
William P. Baker
William Bondy

## State Museum Staff

Charles C. Adams Ph.D., D.Sc. . . . . . . . . . . . *Director of the Museum*
Jacob Van Deloo . . . . . . . . . . . . . . . . . . . . . . *Secretary of the Museum*
Rudolf Ruedemann Ph.D. . . . . . . . . . . . . . . . . . . *State Paleontologist*
Ephraim P. Felt D.Sc. . . . . . . . . . . . . . . . . . . . . *State Entomologist*
Homer D. House Ph.D. . . . . . . . . . . . . . . . . . . . . . . *State Botanist*
Chris A. Hartnagel M.A. . . . . . . . . . . . . . . . . *Assistant State Geologist*
Sherman C. Bishop Ph.D. . . . . . . . . . . . . . . . . . . . . . . . . . . *Zoologist*
Douglas B. Young[1] . . . . . . . . . . . . . . . . *Assistant State Entomologist*
Winifred Goldring M.A. . . . . . . . . . . . . . . . . . . . . . . . . *Paleobotanist*
Noah T. Clarke . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Archeologist*
William T. Shaw Ph.D. . . . . . . . . . . . . . . . . . . . . . *Assistant Zoologist*
Neil Hotchkiss M.A. . . . . . . . . . . . . . . . . . . . . . . . *Technical Assistant*
Kenyon F. Chamberlain . . . . . . . . . . . . . . . . . . . . *Technical Assistant*
Walter J. Schoonmaker . . . . . . . . . . . . . . . . . . . . *Technical Assistant*
Clinton F. Kilfoyle . . . . . . . . . . . . . . . . . . . . . . . *Technical Assistant*
Arthur Paladin . . . . . . . . . . . . . . . . . . . . . . . . . . *Technical Assistant*
Edwin J. Stein . . . . . . . . . . . . . . . . . . . . . . . . . . *Technical Assistant*
Harry C. Wardell[2] . . . . . . . . . . . . . . . . . . . . . . *Technical Assistant*

## Honorary Curators

William L. Bryant . . . . . . . . . . . . . *Honorary Curator of Fossil Fishes*
Benjamin W. Arnold . . . . . . . . . . . *Honorary Curator of Ornithology*
Harry S. Peck . . . . . . . . . . . . . . . . . . *Honorary Curator of Minerals*

## Temporary Scientific Appointments

Francis Harper Ph.D. . . . . . . . . . . . . . . . . . . . . . . *Assistant Zoologist*
Clair A. Brown B.S. . . . . . . . . . . . . . . . . . . . . . . . *Assistant Botanist*
Robert Balk Ph.D. . . . . . . . . . . . . . . . . . . . . . . . *Assistant Geologist*
R. J. Colony B. Ch. . . . . . . . . . . . . . . . . . . . . . . . *Assistant Geologist*
Nelson T. Dale Ph.D. . . . . . . . . . . . . . . . . . . . . . *Assistant Geologist*
A. K. Lobeck Ph.D. . . . . . . . . . . . . . . . . . . . . . . . *Assistant Geologist*
Burnett Smith Ph.D. . . . . . . . . . . . . . . . . . . . . . . *Assistant Geologist*
George H. Chadwick M.S. . . . . . . . . . . . . . . . . . . *Assistant Geologist*
D. H. Newland B.A. . . . . . . . . . . . . . . . . . . . . . . *Assistant Geologist*

[1] Died April 5, 1926.
[2] Transferred March 1, 1926.

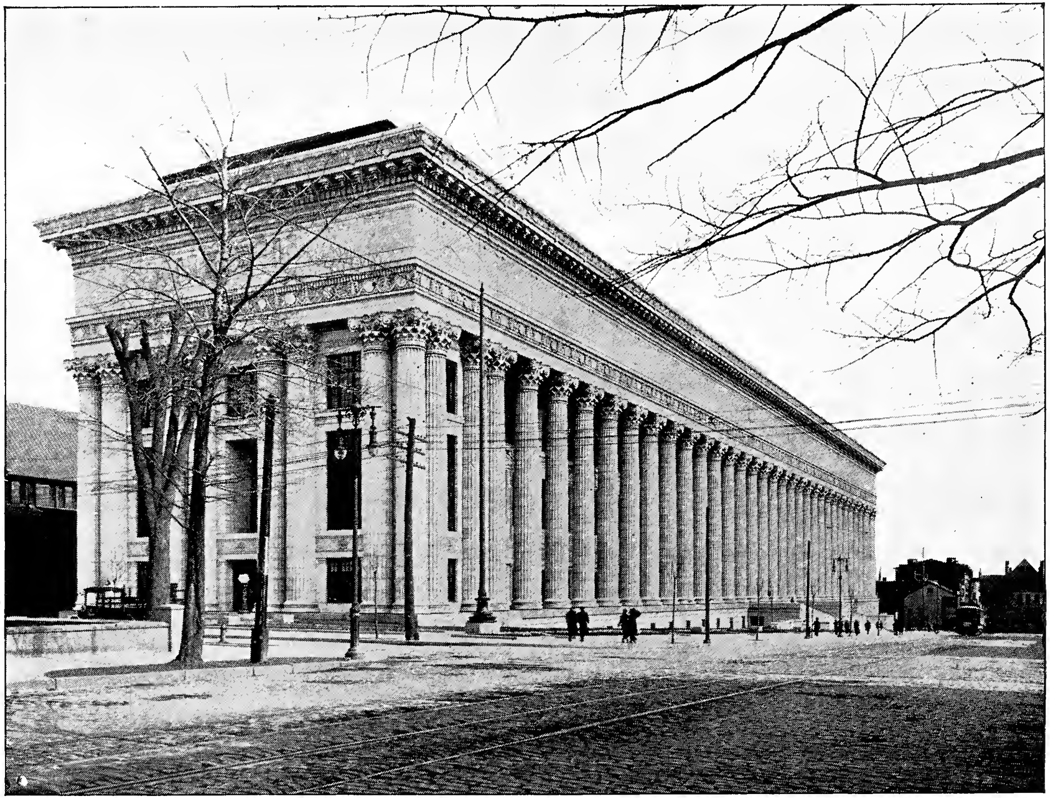

Figure 1 New York State Education Building
On the upper floors is the home of the New York State Museum

# New York State Museum Bulletin

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## New York State Museum

Charles C. Adams, *Director*

# TWENTY-SECOND REPORT OF THE DIRECTOR

## INTRODUCTORY NOTE

This report covers the period from January 1, 1926, to June 30, 1927. For several years these reports have covered the calendar year, but the present one will make the transition to that of the state fiscal year. During the period from January 1, 1926, to May 1, 1926, when the present Director began his duties, the Acting Director, Jacob Van Deloo, had charge, and he has kindly furnished me with the record for that period, so that this report connects directly with the previous report.

## A BRIEF STATEMENT OF THE CURRENT STATUS OF THE MUSEUM

The outstanding activities of the Museum since the previous report may be briefly summarized as follows:

1 **Staff of the Museum and its activities.** In addition to the routine, administrative and curatorial duties, the regular educational scientific and economic work of the staff is devoted primarily to conducting scientific surveys of the natural resources of the State, including geology and natural history and their relation to the allied industries and to education.

As a bureau of information, the Museum carries on an extensive correspondence, estimated at about 8000 letters a year. There is a widespread demand for the Museum publications, particularly for those on geology, entomology, and for the bird and wild flower books, which are on sale.

2 **Condition of the exhibitions and collections.** Largely on account of the lack of space, no especially important new collections have been placed on exhibition. New exhibits are needed, as some

have remained unchanged for several years and therefore have lost their freshness. The study collections have been carefully inspected and are in as good condition as their crowded quarters and the storage facilities permit.

3 **Accessions.** Valuable accessions, or additions to the collections, have resulted from the investigations made by the members of the staff, particularly in the field. By gifts and exchanges many valuable additions have also been made, and a few purchases have added to the collections. The larger and more noteworthy gifts are:

From Catharine E. B. Potter, Whitehall, N. Y., the Rear Admiral E. B. Potter Collection of Spanish War and battleship "Maine" relics

From Mrs Carmelita Martin, Ringville, Mass., framed picture of birthplace of Joseph Henry, Albany, N. Y.

From the estate of Mrs John Boyd Thacher, Albany, N. Y., four Iroquois Wampum belts, including the largest one known. This is a very valuable addition to the collection

From Dr August F. Foerste, Dayton, Ohio, a valuable collection of Brachiopod fossils

From Professor M. Gortani, Bologna, Italy, a collection of Silurian graptolites

From Dr Gustaf Troedsson, Stockholm, Sweden, a collection of Swedish graptolites

From W. P. Alexander, Buffalo, N. Y., a large collection of fishes, reptiles and amphibians from the Allegany State Park

4 **Museum attendance.** Automobile transportation has greatly increased the number of visitors to the Museum. It is estimated that about 200,000 persons visit the Museum annually, the majority of these between June 15th and September 15th, when the number of tourists is greatest. If we allow two hours for a visit, at the rate of 50 cents an hour the public is receiving free $200,000 worth of educational recreation each year from the State Museum.

A large number of the visitors are from outside of the State, and consequently the exhibits are a valuable advertisement for the State. More than 200 groups of school children came by automobile. One group traveled 140 miles. The Sunday attendance is largely local.

5 **Cooperation with state and other organizations.** In addition to cooperation within the Education Department, particularly in the exchange of publications through the State Library, and with the office of the State Historian, the Museum has cooperated with the following:

Joint Legislative Commission, on the location of the Lake Champlain Bridge

The New York State Oil Producers Association, on the Tercentenary of the discovery of oil, at Cuba, N. Y.

United States Bureau of Mines and United States Bureau of Census, Washington, D. C.

New York State College of Agriculture, Cornell University
New York State Department of Agriculture and Markets
New York State Department of Health and State Health Laboratory
United States Bureau of Entomology, Washington, D. C.
United States National Museum, Washington, D. C.
Buffalo Society of Natural Sciences, Buffalo, N. Y.
Allegany State Park Commission, Salamanca, N. Y.
State Council of Parks and Supervisor of Pest Control, New York State Department of Conservation
Colgate University, Department of Geology and Geography, Hamilton, N. Y.

6 **Administrative organization.** As it is about 90 years since the work now conducted by the Museum was started, and publication has been one of the leading activities of the Staff, a complete set of the publications now covers about 40 lineal feet of shelving. On account of the inadequate provision for storage in the Museum, these publications have been scattered from the basement to the top of the Education Building. Many of the publications are out of print and the available ones are so scattered that it is difficult and time-consuming to secure them for applicants. The quality of these publications is generally recognized as of a very high order and they are therefore worthy of appropriate attention and care. An inventory of these has been begun, and from two to three men have been busy much of the time getting them listed and in order, and many months' work is yet ahead before this inventory can be completed.

The Museum collection of drawings, maps and photographs has become extensive, but on account of inadequate storage facilities these have been widely scattered. New steel filing cases have now been installed and these materials are being concentrated, organized and indexed according to a simple system, and as well with a certain amount of standardization. Only a beginning has been made on this large undertaking, but when once functioning, it will aid greatly the work of the entire staff.

## COOPERATION WITH STATE AND OTHER ORGANIZATIONS

The work of a modern scientist and educator is so complex that he is seldom an isolated worker. The State Museum occupies a unique position in the State in relation to its accumulated data on the natural resources of the State, particularly in respect to educa-

tion and the industries. As a result of these conditions there is much cooperative work. Dr Rudolf Ruedemann, State Paleontologist, is editing a two-volume Geology of North America, which involves the cooperation of more than 20 leading American geologists. The result will be a work of great scientific and educational value. The Morrisville quadrangle is being surveyed in cooperation with the department of geology and geography of Colgate University, Hamilton, N. Y. Chris A. Hartnagel, Assistant State Geologist, has cooperated with the Joint Legislative Commission on the location of the Champlain bridge (Legis. Doc. No. 59, 1927); with the New York State Oil Producers Association on the tercentenary of the discovery of oil at Cuba, N. Y., and with the United States Bureau of Mines and the Bureau of the Census on mineral statistics. Dr E. P. Felt, State Entomologist, has cooperated on the corn borer with the State College of Agriculture, and the State Department of Agriculture and Markets; on the Japanese beetle with the Department of Agriculture and Markets; on insects and health with the State Department of Health and the State Health Laboratory; on the relation of insects and winds, with the State Department of Agriculture and Markets; on forest insects with the Supervisor of Pest Control, State Department of Conservation, and the United States Bureau of Entomology; on gall midges with the United States National Museum. Dr Homer D. House, State Botanist, has cooperated on a plant survey of the Allegany State Park with the Buffalo Society of Natural Sciences and the Allegany State Park Commission. Dr Sherman C. Bishop, Zoologist, also cooperated with the Buffalo Society of Natural Sciences and the Allegany State Park Commission on a study of the reptiles and amphibians of the park, with Professor C. R. Crosby of Cornell University on certain studies of spiders, and with the State Conservation Department. Walter J. Schoonmaker, Technical Assistant, has also cooperated in the Allegany State Park work. Dr A. K. Lobeck, Assistant Geologist, cooperated in the Allegany State Park with the Buffalo Society of Natural Sciences on a guide to the local geology.

The staff cooperated with the Editor of the Department in the preparation of the Arbor and Bird Day numbers of the Bulletin to the Schools.

The Director, as a member of the State Council of Parks, has attended every meeting possible and has cooperated, on invitation, with the Allegany State Park Commission and the Letchworth-Genesee Valley Commission, and the Finger Lakes State Park Commission on problems involving educational and museum policies.

The largest single cooperative undertaking has been with the Buffalo Society of Natural Sciences and the Allegany State Park Commission, as discussed below.

The Museum has had hearty cooperation with the office of the State Historian, who has aided materially in our efforts to secure valuable historic objects. The State Library has also cooperated very substantially. It is through the Library that the exchange of Museum publications is conducted, and large additions are made to the Library by this means, to which reference is made elsewhere.

## ALLEGANY SCHOOL OF NATURAL HISTORY

The relation of the Museum to the schools and colleges of the State is shown not only by the visitors to the exhibits but as well by its numerous publications, the requests of teachers and pupils for information and advice and the requests for talks and lectures by members of the staff. By these methods the Museum reaches in the course of the year the whole gamut of the educational system from the kindergarten to adult education, and contributes as well technical advice to public officials.

The Regents have expressed their desire to have the Museum do more for our schools, and the staff is willing and eager to do all it can. Therefore when Chauncey J. Hamlin, president of the Buffalo Society of Natural Sciences and a Commissioner of the Allegany State Park, invited the Museum to cooperate with the two agencies which he represents, in conducting a school devoted primarily to the study of outdoor natural history and park management in the Allegany State Park, his offer was heartily welcomed as one more chance to open up a new field for the training of leaders for our schools, colleges and camps, a line of work in urgent need of constructive leadership. Upon the approval of this plan by the Regents, an excellent staff was secured with the cooperation of the Buffalo Society of Natural Sciences. The Park Commission furnished the school buildings, which have a capacity for 50 students, and the Buffalo Society of Natural Sciences administered the dining hall and allied finances the Museum furnishing cooperative supervision of the educational policies and contributing a series of guide books on the natural history of the park region. Through the hearty cooperation of the State Library and the Traveling Library, the Museum and certain friends, a fine working library was furnished to the school. Although the plans were made during the period of this report, the session was held beyond that period, from July 5th

to August 31st. It may be mentioned, however, that the school was conducted with great success under the able supervision of Dr Robert E. Coker, its director. The Museum contributed three handbooks, which were of special value.

## RELATION OF THE MUSEUM TO SCHOOLS AND COLLEGES

During the past year more than 200 groups of pupils have visited the Museum, averaging 28 persons to a group and representing 13 counties, Albany, Rensselaer, Columbia, Greene, Saratoga, Montgomery, Washington, Schenectady, Hamilton, Oneida, Herkimer, Orange and Otsego. While the attendance from rural sections dropped off somewhat, the visitors came from even greater distances than in previous years by using the automobile busses. One group of pupils came from Indian Lake Village, Hamilton county, by bus during June. They left home at 5 a. m. and arrived at the Museum at 2 p. m., returning that day. To provide for the trip, special funds were raised during the preceding winter. This shows an appreciation of the value of visiting the Museum and excellent enterprise and spirit.

In addition to the public school pupil visitors, 575 college and normal school students made special visits to the Museum, including some from outside of the State.

A record of the visiting schools, made between May 26 and June 26, 1926, showed that 25 classes averaging 20 pupils each visited the Museum. Most of these visitors were from rural districts. Classes from cities, for the most part from Albany, Troy and Schenectady, averaged between 35 and 40 pupils. An estimate for the past year is about 200 classes and approximately 6000 pupils.

Since the advent of the automobile bus, it has been the custom for teachers within easy reach of Albany to bring their classes to the Museum as a special outing and excursion. Many of these teachers require reports of their pupils on the trip, and copies of these reports which have been sent to the Museum show that the children gain much benefit from these excursions. The best procedure is for the teachers to write in advance to the Secretary of the Museum so that preparations may be made for their arrival.

## MUSEUM ATTENDANCE

We have no accurate method of determining the total attendance at the Museum. From June 15th to September 15th there is a large

attendance of automobile tourists, as Albany is so located that great numbers visit here and include the Museum and the Capitol in sightseeing trips. These people are from all over the United States and Canada. The influence of these visitors is thus far-reaching. The visitors during the winter, including Sundays, are largely local.

The total annual attendance is roughly estimated to be about 200,000. This is based on seasonal calculations as follows:

| | |
|---|---|
| June 15th to July 1st, about | 10 000 |
| July | 40 000 |
| August | 50 000 |
| September 1st to 15th | 10 000 |
| Open 30 Sundays | 45 000 |
| Remainder of the year | 45 000 |
| Total number of visitors | 200 000 |

## MUSEUM AS A BUREAU OF INFORMATION

A constant stream of inquiries comes to the Museum from visitors to the exhibits, by telephone calls and through an extensive correspondence covering every phase of Museum work, including such varied subjects as rocks, minerals, fossils, plants, insects, birds, fish, Indian relics and the Museum publications. The geologists are consulted on fossils and rocks, and about road materials, the location of bridge piers and dams. As examples of this, aid has been given to the State Highway Department with regard to the location of bridges, and the Commissioners of the Allegany State Park have consulted the staff on the location of a dam. It is considered one of the important functions of the Museum to assist in these matters in every possible way. In the course of the year perhaps 8000 letters of this character are answered.

## CONDITION OF EXHIBITIONS AND COLLECTIONS

The condition of the exhibits and the collections is generally satisfactory, except for limited storage facilities.

The collections have increased as a result of field work by the Museum Staff, exchanges, donations and a few purchases. Important collections of plants, reptiles, amphibians and mammals were made by the staff while conducting cooperative studies in the Allegany State Park with the Buffalo Society of Natural Sciences and the Allegany Park Commission. Exchanges have resulted in valuable fossils new to the collections.

## HISTORICAL AND ARCHEOLOGICAL COLLECTIONS

"I warmly sympathize with the ambition expressed in your annual report to have this Museum more than a mere zoologic or scientific museum. It should be a museum of arts and letters as well as a museum of natural history. . . . There should be here a representation of all our colonial and revolutionary life. There should be in this Museum, for the instruction and inspiration of our people, a full representation of American history since the time when New York cast off its provincial character and became an integral portion of the American republic."—*Theodore Roosevelt's address at the opening of the New York State Museum, December 29, 1916.*

The historical collections of the Museum have been accumulating since 1843. In the First Annual Report of the Regents for 1847, reference was made to this early collection. These collections have not grown, however, as their merit would lead one to expect, and yet, when it is considered as a whole, the collection is really of considerable value. In 1853 the Regents published a catalog of the historical collection, but none has been published since. Of course the rather extensive ethnological and archeological collection devoted to the Indians is in reality a phase of history, but this collection was almost wholly destroyed by the fire in the Capitol in 1911. Since that time a new collection has been built up and many of the best materials are now on exhibition. The study series, however, is not extensive. The well-known Indian groups are among the outstanding features of the Museum. Perhaps the most important part of all is the series of Iroquois wampum belts purchased by the State from the Onondaga Indians. In May 1927 the Museum received from the estate of the late Mrs John Boyd Thacher, four more wampum belts, as listed among the accessions, which make the Museum collection the most valuable of its kind in existence from a historical point of view. The Washington Treaty Belt is the largest known piece of wampum. The belts have been described or figured elsewhere in the publications of the Museum (Bulletin 41, by Beauchamp, and Bulletin 125, by Converse and Parker).

The New York State Agricultural Society at one time had a museum but later abandoned it, and the New York State Fair Commission transferred this collection to the State Museum in 1901, where it has been cared for ever since, even in our crowded quarters. In 1920 the Museum sent out a circular to farmers, inviting them to send in historical objects. During the spring and summer of 1924, the Museum had a man in the field collecting household and agricultural objects, so that this collection, particularly the series of plows, is now of special historic value.

Other recent valuable historic accessions worthy of special mention are:

A collection of Spanish War relics made by Rear Admiral William P. Potter, including objects from the battleship "Maine," sunk February 15, 1898. Presented by his daughter Catharine E. B. Potter

A framed picture of the Albany birthplace of Joseph Henry, presented by Mrs Carmelita Martin, through W. F. Jacobs

Hand-made wooden cheese press, shoemaker's bench, shoe lasts and flail, presented by Mrs S. P. Ambler

Roosevelt Medal, from the Woman's Roosevelt Memorial Association, through the late Regent Alexander

Belgian medals and plaque, from the Commission for Relief in Belgium, through Dr C. R. Richards

Framed plate of crow by John J. Audubon, presented by Gilbert M. Tucker

As a part of the historical collection, the Museum has valuable objects used by Dr Joseph Henry, the physicist and first secretary of the Smithsonian Institution. A start has thus been made toward the memorializing of one of New York's greatest scientists. There are also in the collection, objects formerly belonging to Dr James Hall, who more than anyone else was responsible for the real foundation of this Museum. It seems eminently appropriate that the State Museum should give special attention to these illustrious men who have played a leading rôle in state and national development in scientific matters. Every opportunity is being taken to develop this phase. The Museum was therefore greatly pleased when, through the interest of Mrs George R. Boynton of New York City, Mrs Nellie Garretson Gunther became interested in its activities. She is the literary administratrix of Admiral Charles D. Sigsbee, who was commander of the battleship "Maine" at the time of its sinking, February 15, 1898, in Havana harbor. The admiral was born in Albany. It is important to recall in this connection what is not so generally known, that Sigsbee made scientific discoveries and inventions in deep sea research of outstanding merit. That his work, both scientific and naval, should be commemorated in the Museum, is thus very appropriate. Mrs Gunther has pledged (and already has turned over, as this report goes to press), a Sigsbee collection to the Museum, which is of great interest and value.

The Sesquicentennial celebration conducted by the State under the direction of the Regents has aroused great interest this year in New York history, and as a consequence many historic objects have been called to the attention of the State Historian, Dr A. C. Flick, who has cooperated with the Museum in securing such collections,

## STAFF OF THE MUSEUM AND ITS ACTIVITIES

"It is essential that this Museum should command the services of many different men for work in many different fields, and that its work should be so closely related to work of the same kind elsewhere that it shall all represent a coordinated whole. This is true of all departments of the work, but especially so of those departments which have a direct utilitarian bearing.

"This Museum, like every other institution of the type, should do everything to develop large classes of workers of this kind. And yet, friends, we must never forget that the greatest need, the need most difficult to meet, is the need to develop great leaders and to give full play to their activities. In the entirely proper effort to develop numbers of individual workers there must be no forgetfulness of this prime need of individual leadership if American achievement in the scientific field is to be really noteworthy. Yet in scientific as well as in historical associations and academies, this fact is often forgotten.

"The really great works must be produced by some individual great man who is able to use to the utmost advantage the indispensable preliminary work of a multitude of other observers and investigators. He will be the first to recognize his debt to these other observers and investigators. If he does not do so he will show himself a poor creature. On the other hand, if they are worth their salt they will be proud to have the great architect use all the results of their praiseworthy and laborious and necessary labor in constructing the building which is to crown it."—*Theodore Roosevelt's address at the opening of the New York State Museum, December 29, 1916.*

In recent years there has been much discussion in scientific literature about the advantages and disadvantages of organizing scientific work and workers. As is usually the case in such problems, the practical difficulty is to strike the mean between enough freedom to allow real ability not merely to exist but to thrive, and enough organization to prevent unnecessary waste of ability and resources on the part of the less able and efficient.

The method of having a definite written plan has many advantages. It encourages definite ideas as to aim and procedure on the part of the worker, and aids planning ahead and cooperation on the part of the other officials. In general, other things being equal, it seems the best general procedure to concentrate on a few *definite projects* rather than to dissipate ability and the funds of an institution along many lines of indefinite action. For this reason an effort has been made to encourage the project system, and the work of the Museum is as much as possible being conducted upon this plan.

For several years the United States Department of Agriculture has published a volume outlining the research and other projects conducted by the Department. An adaptation of this general plan,

applied to our work, gives the following general headings for dealing with various subjects:

*Project No.* (Subject.)
*Scope.* (To determine etc.)
*Status.* (Its present stage etc.)
*Plans.* (For future etc.)
*Finances.*

The following is a brief sketch of the major work of the Scientific Staff, in addition to the usual office and administrative work:

**Geology.** The paleontological work has been devoted to the continuation of studies of graptolites, the editing by Doctor Ruedemann of a comprehensive work by about 20 authors, on the Geology of North America, and field work on the Lowville and Troy Quadrangles. His second report on the Utica and Lorraine formations also appeared as a Museum bulletin.

In spite of a period of ill health, Winifred Goldring has made considerable progress on a popular introduction to paleontology, and progress has been made on the Berne quadrangle, which includes the John Boyd Thacher State Park. Superintendent John H. Cook, of this park, who is an experienced geologist, will cooperate in this.

In the field of economic geology, the report by Mr Hartnagel on mining and quarry statistics from 1919–24, brings that subject to date and in readily accessible form (Bulletin 273). This report shows that mining and quarry products exceed in value $100,000,000 each year, an increase of $25,000,000 since 1920. This is about twice the value of these products from all of New England.

Dr A. K. Lobeck completed the field work and finished his popular report on the geology and physiography of the Allegany State Park region and has produced a very valuable guide to that region. Geological reports have appeared by Doctors C. H. Smyth jr and A. F. Buddington, on the Lake Bonaparte Quadrangle; by Dr F. Holzwasser, on the Newburgh Quadrangle and Vicinity, and by Dr W. J. Miller, on the Lyon Mountain Quadrangle.

**Insects.** Doctor Felt reports the discovery of three very injurious beetles in southeastern New York—the Japanese beetle, the Asiatic beetle and the Japanese serica. The European corn borer injury continues and demands serious attention. A new and serious type of injury by the Pales weevil to young pines has been demonstrated. It requires constant vigilance to protect our crops from such harmful insects. Studies of the dispersal of insects by winds and the

study of gall midges have been continued. Great numbers of wind-dispersed insects have been taken from the roof of the Education Building and the results have been new and surprising. H. L. Viereck's report on the Hymenoptera of the Museum collections has been completed. A concise system of indexing the insect collection has been started. Kenyon F. Chamberlain has begun work on a descriptive catalog of the beetles of the State and an intensive study of Lupine insects.

**Plants.** Doctor House has conducted a field study and prepared a report in cooperation with W. P. Alexander on the flora of the Allegany State Park. This is to serve as a guide to the plants of the region. Field work has also been continued in the Newcomb region of the Adirondacks and at the eastern end of Oneida lake. Neil Hotchkiss has assisted greatly in the herbarium and has made material progress on both the field work and his report on the vegetation of the Tug hill region, west of the Adirondacks.

**Animals.** Doctor Bishop has devoted considerable time to field study in several parts of the State and has prepared a report in cooperation with W. P. Alexander on the reptiles and amphibians of the Allegany State Park. His paper on the habits and development of the Mudpuppy, appeared as a Museum Bulletin. He has continued his investigations in cooperation with Professor Crosby, on the spiders of the State.

Dr Francis Harper continued his study of the mammals of the region about Mount Marcy, in the Adirondacks. Walter J. Schoonmaker has given special attention to the local mammals, particularly the Woodchuck, and devoted a limited time to field work in the Mount Marcy region and in the Allegany State Park. Professor J. W. Bailey has completed a report on the myriapods of the State, based largely on the collections of the Museum.

Dr W. T. Shaw has begun an intensive study of the life history and habits of the Skunk, one of the most valuable fur-bearing animals in the State, and about which we have very little detailed knowledge.

**Archeology.** Noah T. Clarke has been largely occupied with cataloging the study collection. He has also indexed the archeological articles printed in the Museum publications so that these are easily accessible. Life busts of a number of Indians have been bronzed and placed on exhibition.

We wish to record with regret the death during the interval of this report of three former members of the Museum scientific staff.

Dr James Furman Kemp died November 17, 1926. Doctor Kemp was for many years a member of the staff and was one of the three pioneers on the Precambrian Adirondack geology, the other two being Professors Smyth and Cushing.

Dr Charles D. Walcott died February 9, 1927. Doctor Walcott, as a young man, was an assistant of Dr James Hall on the Museum staff. In this, his first scientific position, he secured important scientific training.

Douglas B. Young, Assistant State Entomologist, died April 5, 1926. He filled this position very efficiently for 24 years.

At this place mention should also be made of the loss of Regent Charles B. Alexander, Chairman of the Museum committee of the Board of Regents. Regent Alexander had been chairman of the Museum committee since 1913, and gave considerable time to the welfare of the Museum. He died on February 7, 1927. He has been succeeded by Regent Wm Leland Thompson, as chairman.

## LOSS OF THE STATE SCIENTIFIC RESERVATIONS

"There must be ample research in the laboratory in order even to present those problems, not to speak of solving them, and there can be no laboratory study without the accumulation of masses of dry facts and specimens.

"I also mean that from now on it is essential to recognize that the best scientific men must largely work in the great out-of-doors laboratory of nature. It is only such out-of-door work which will give us the chance to interpret aright the laboratory observations."—*Theodore Roosevelt's address at the opening of the State Museum, December 29, 1916.*

The preceding Director of this Museum, Dr John M. Clarke, after years of effort secured private funds for the purchase of certain reservations which were primarily to be preserved for their scientific and educational value. These he aptly called the "Out-of-Doors Museum." This gave to the State a small and unique system of reservations somewhat comparable to the federal national monuments, in that they were intended to be preserved from economic exploitation or from the overuse or abuse, to which certain park areas are subjected. No other state had such a series of such reservations. As Doctor Clarke said, *"They have not been taken over for park purposes but to preserve their natural attractions unimpaired."* This aim corresponds to the purpose of the national parks, which were intended to be passed on "unimpaired" to future generations, which has come to mean in a wild state. With our increasing population, its industrialization and concentration in cities, there has been

an increased demand for public parks and forests for recreation. Forest policies for economic purposes have not yet clearly recognized the value of such wild and natural reservations. As might be anticipated, the main difficulties of preserving these scientific and educational reservations have been to provide for their *maintenance* and to select the correct sites. These reservations, formerly under the custody of the State Museum, were as follows:

1 Clark Reservation, 115 acres, near Jamesville, N. Y.

2 Chittenango Falls Park, 22 acres, near Cazenovia, N. Y.

3 Lester Park or Cryptozoon Ledge, 3 acres, near Saratoga Springs, N. Y.

4 Stark's Knob, 4 acres, near Schuylerville, N. Y.

5 Squaw Island, Canandaigua Lake

Clark and Chittenango Falls reservations were transferred to the custody of the Central New York Park Commission, with the reorganization of the State Government (State Departments Law, chapter 619, Laws of 1926) on January 1, 1927. The remaining reservations were transferred to the Conservation Department.

Had these reservations been given *in trust* to the State Museum, this transfer could not have been made, although in the cases of Clark Reservation and Chittenango Falls Park there was much to be said for them as parks, rather than as reservations, because the geologic features, for which the Clark Reservation was primarily set aside, could be maintained in a park, although this is not equally true of the plants and animals of an area used as a picnic grounds and for intensive park purposes.

The loss to the Museum of these Reservations is significant because it reveals anew a condition deserving of public attention. Primeval nature in eastern America is being destroyed so rapidly that even today one may have to travel hundreds of miles to see a patch of virgin woods, and thousands of persons do not even know at sight how to recognize virgin conditions of nature. In this respect we are fast approaching European conditions, where there is little left of undisturbed nature. We can, however, learn from their mistakes if we will begin in time. Let us consider first of all:

**Virgin conditions.** These conditions are given special emphasis because of their rapid extinction, inert public interest in them, their rare beauty and unique value of such regions from the esthetic, educational and scientific points of view.

Wild, undisturbed nature has a uniqueness comparable to that of the works of the greatest literary men and artists, and any change

made by man injures them to some degree, just as it would to "improve" upon the work of Shakspere, Muir, Leonardo or Rembrandt. We need some "unimproved" samples of wild nature—just as nature made them—because of their *unique qualities.* Their esthetic value is recognized at sight, as can be seen in most of our national parks, and their educational values are equally important. These areas may be looked upon in part as the historic remnants of ancient America as the pioneers first saw it. Our early pioneer life was molded in this setting. Our entire school system from the kindergarten to the university needs these historic relics for teaching purposes; our naturalists will always find a unique charm and innumerable problems for study in such conditions; and finally they are needed for a high grade of recreation.

Some large tracts of land are urgently needed, particularly in those regions where national parks can not and should not be established. There should be set aside in the national and state forests and in state parks—which are yet fortunate enough to possess virgin conditions—the best available samples of these conditions, where they can be preserved indefinitely unharmed for future generations.

The preservation of these areas is particularly difficult because of the frequent tendency on the part of public officials to make a showing of "improvements," and because of the belief that such "improvements," so called, will not injure such areas or reservations. The rotten logs, dead trees and similar features that irritate the formal park official or economic forester, are essential in a wild natural history preserve, as they are a part of the natural system which it is primarily intended to preserve. In such a preserve the greatest difficulty will therefore be to "leave it alone," and to prevent its destruction by allowing the public, unsupervised, to overrun and destroy it, as is being done even today in parts of some of the finest national and state parks.

**Restored areas.** In regions which have already lost their natural conditions, an effort should be made to preserve samples of the best remaining and least injured examples, in order that such areas under competent supervision may be allowed *to return to nature* and ultimately become valuable substitutes for original conditions. This is particularly true where all the surrounding regions have become intensely modified, artificial and formal.

At present, as has been said, we have no adequate recognition and supervision for the preservation of reservations that are primarily of scientific and educational value, and requiring scientific and educational supervision. Examples of tidal swamps, sand dunes, cat-tail

swamps and other representative natural environments are desirable for such reservations but today are not wanted as parks. Such areas should be supervised differently than the conventional rural or urban parks and forests, and require a special staff, composed of competent naturalists, whose special knowledge is necessary not only to care for such property but to enable them to conduct investigations on such reservations, as this is one of their main uses. Furthermore, part of such a staff might act as guides for the visiting public. Such areas, carefully selected in various parts of the State, in order to preserve enough important samples, would be of the greatest importance from an educational and scientific point of view and would truly be "outdoor museums." Parts of these, particularly when properly labeled, would be wild plant and wild animal gardens.

There are additional reasons why the Museum needs land for conducting its own investigations of the native plants and animals. The State Entomologist's office, even after 53 years of valuable existence (established in 1874), has not a single acre of land upon which to conduct experiments on injurious insects, or a field laboratory of any kind. This was not remarkable fifty years ago, but today this is distinctly not in accord with modern standards. In the spring of 1927, when the Museum was making investigations on the habits and life history of the Skunk, it was necessary to rent land in order to care for these animals. Until suitable tracts of land are secured for the Museum, its work will be seriously hampered and can not be conducted as it should be.

During the past 25 years there has been a wonderful development of educational and research institutions in this country. Some have grown through private endowment, others are financed by the State or the federal Government, and still others by a combination of both public and private support. Strange as it may seem, this cooperative plan has been one of the most successful. Not only do colleges, universities and research institutions gain by these methods, but parks and historic and scientific reservations have been established and conducted by these same methods. Aside from the Adirondack and Catskill parks, in the main the early development of the parks, historic and scientific reservations in this State was by the private method, and these have grown into the present State Park and reservation system. The Palisades Interstate Park on the Hudson is a fine example of this kind of development.

In that case large private funds were turned over to public officials, the income of the funds providing for the development of that park area. Similar funds, in trust, given or bequeathed to the Board of

Regents, for the development of the State Museum, would permit the purchase of natural history reservations, their maintenance and the production of exhibits, *in advance* of the slower moving public sentiment needed for legislative support, and would allow the Museum to develop, as it should, a credit to the wealthiest state in America.

Particular attention should be called to the fact that several of the most striking and beautiful exhibits in the Museum, as for example the Indian Iroquois Groups, and the scientific reservations, were not financed by the Legislature but by the gift of funds secured by the former Director, Dr John M. Clarke.

To those who recognize the need of such reservations, the following suggestion is made.

Gifts up to 15 per cent of the net income and all bequests to the Board of Regents of The University of the State of New York, *in trust* for the State Museum, are exempt from federal taxation, under the Federal Revenue Act of 1918.

## PUBLICATIONS AND THEIR STORAGE

A single set of the various Museum publications requires 40 lineal feet of shelving, the result of about 90 years of productive activity. Many of these publications are now out of print or are very rare. At times in the past the editions were large, but with the increased cost of printing there has been a great reduction in the size of editions. As the result of various influences, particularly the lack of adequate storage facilities, these publications have been stored from the basement to the top of the Education Building so that it was often impossible to know what publications were in stock or where they were.

For many months now, from two to three men have been devoting most of their time to taking an inventory of these publications, sorting and arranging them. Storerooms and shelving have been built to the extent of several thousands of lineal feet, and a corresponding amount of the publications have been inventoried. The list of available publications, accompanying this report, is a provisional list based upon this work.

## PUBLIC LECTURES AND PUBLICITY

Frequent calls are made upon the staff for talks and lectures. The record shows that seven speakers have made 73 talks and have thus reached about 8900 persons. These talks have been given in 17 counties, as follows: Albany, Columbia, Erie, Essex, Fulton,

Greene, Jefferson, Kings, New York, Oneida, Onondaga, Orange, Otsego, Rensselaer, Rockford, Saratoga and Schenectady. Seven of these talks were given outside of the State. Press notices have been prepared on various subjects, particularly on economic entomology, and one radio talk was given on the corn borer.

## DRAFTING, PHOTOGRAPHY AND THE STOREROOM

On account of the prolonged and extensive series of publications of the Museum, the accumulated scientific drawings of fossils, insects and other objects are very extensive. It has not yet been possible to estimate their number. Later, with the rise of photography as a means of illustration, such materials have accumulated at a rapid rate. Of the photographic series there are about 5000 negatives and prints and 800 lantern slides. The geological reports have required many maps and line drawings. This accumulation has never been concentrated, systematically arranged and indexed.

The dark room facilities have been inadequate but conditions have been improved considerably.

New cameras of various types have been purchased and other valuable equipment for printing have been acquired, so that the quality of the work by the staff and field parties has been greatly improved. Such equipment not only improves the value of our official records and files but the quality of our publications as well.

Steel filing cases, suitable for negatives, lantern slides, maps and drawings, have been purchased, and the concentration of these materials has been started. Standard photographic equipment, supplies and methods of recording field data have been worked out and are under way. It will, however, require a few years to organize this collection properly with the present limited staff.

All photographic equipment has been placed in charge of Mr Stein, as have also the scientific equipment and supplies, in order to have a central office and storeroom for such materials and a definite system of caring for them and locating responsibility. Additional aneroids, hand levels and other scientific equipment are being acquired as rapidly as funds will permit.

## MUSEUM PRINTING

"After all it is the written word that lives."—*Dr W. M. Beauchamp.*

No modern public museum can retain a staff of high quality, cooperate with the leaders in its field and maintain public confidence and respect without devoting much attention to printing in both

popular and technical form the results of its investigations and activities. Adequate funds for printing are always difficult to secure. For several years these funds for the Museum have been very inadequate, so that there is a considerable accumulation of manuscripts on hand. Some manuscripts have been on hand for many years. When we consider the inadequate payment for most scientific work, delayed publication is an injustice that authors, with good reason, strongly resent. Therefore prompt and satisfactory publication is one of the best possible means of securing hearty cooperation among the scientific men of the State. Furthermore, by this same method, experts are attracted to the State who otherwise would work elsewhere.

The publications of the State Museum are a valuable means of building up the State Library. Not only are these publications sent to libraries throughout the State but to other states as well and abroad in large numbers. By this means the publications of other states and organizations received in exchange total in the course of a year thousands of pamphlets, reports and books, which, if purchased at current market price, would amount to several thousands of dollars. The present mailing list of the State Library, to which the publications of the Museum are sent, amounts to over 700 addresses.

A list of the publications of the Museum and of the members of the staff accompanies this report and is given in the bibliography.

## FINANCIAL AND STATISTICAL SUMMARY

As the period of this report covers a year and a half, the following financial and statistical summary is given for the two fiscal years involved, but in greater detail for the year 1926–27.

**The Museum budget.** The following budgets do not include the cost of heat, light, janitor service, orderlies, carpenters, painters and elevator men. Certain supplies also, are furnished by the Education Department, such as postage, stationery, express, freight, ordinary drayage, telegraph and telephone, and are therefore not included in this budget. Gifts of funds, in addition to that derived from the state appropriation, are indicated.

The traveling expenses have been budgeted, so that each member of the scientific staff is able to plan his work to the best advantage. As rapidly as possible it is hoped to extend this system to all expenditures.

*Appropriations and Funds for Fiscal Year*
*July 1, 1925—June 30, 1926*

| | |
|---|---|
| Salaries: | |
| Administrative staff | $8 500 00 |
| Scientific staff | 18 300 00 |
| Scientific assistants | 10 940 00 |
| Clerical, labor etc. | 8 580 00 |
| Total salaries | $46 320 00 |
| Equipment and supplies | $5 000 00 |
| Temporary services (scientific) | 3 000 00 |
| Traveling (of which not to exceed $200 is available for out-of-State travel) | 2 300 00 |
| Printing | 8 000 00 |
| Supplementary appropriation for printing 10,000 copies of the portfolio of the colored plates of Birds of New York (Laws of New York 1925, chap. 659) | 10 000 00 |
| Special fund for Sunday opening | 1 020 00 |
| Total appropriation | $75 640 00 |

*Appropriations and Funds for Fiscal Year*
*July 1, 1926—June 30, 1927*

| | |
|---|---|
| Salaries: | |
| Administrative staff | $9 000 00 |
| Scientific staff | 23 840 00 |
| Scientific assistants | 8 000 00 |
| Clerical, labor etc. | 8 760 00 |
| Total salaries | $49 600 00 |
| Equipment and supplies | $5 000 00 |
| Temporary services (scientific) | 3 000 00 |
| Traveling (of which not to exceed $200 is available for out-of-State travel) | 2 300 00 |
| Printing | 8 000 00 |
| Special fund for Sunday opening | 1 020 00 |
| Total appropriation | $68 920 00 |

The expenditures utilize these funds so fully that the balance unexpended is negligible.

*Statistical summary*

| | |
|---|---|
| Estimated number of visitors a year | 200 000 |
| More than 200 groups of school children and student visitors (annual estimate) | 6 000 |
| College and normal school student visitors (current fiscal year) | 575 |
| Cooperation with organizations (current fiscal year) | 12 |
| Complete set of Museum publications, in lineal feet | 40 |
| Museum file of photographs, negatives and prints (estimated) | 5 000 |
| Lantern slides (estimated) | 800 |
| Correspondence of the staff, letters (annual estimate) | 9 000 |
| Number of persons reached by public lectures and talks (current fiscal year) ... Over | 8 900 |

*Directory Data*

*Name of Museum:* New York State Museum
*Location:* Albany, N. Y., U. S. A.
*Name of Director:* Charles C. Adams
*Name of secretary:* Jacob Van Deloo
*Date of founding:* The Museum is the outgrowth of state surveys begun in 1835; formal organization of the Museum was in 1843.

**Open to the public.** Open week days from 9 a. m. to 5 p. m., and Sundays from 2 to 5 p. m. from October 4 to April 25, 1925–26, 30 days; from October 3 to April 24, 1926–27, 30 days

| | | |
|---|---|---|
| Total number of hours open to the public a year | | 2 518 |
| Number of members on scientific staff | 9 | |
| Number of clerical employees and others | 13 | |
| Number of part-time persons (scientific) | 9 | |
| Total staff | 31 | |

**Salary schedules,** 1926–27

| | |
|---|---|
| Director | $6 000 |
| Secretary | 3 000 |
| Scientific professional staff | $1 440 to 4 250 |
| Technical assistants (nonprofessional grade) | $1 380 to 2 000 |

**Hours and vacation**

| | |
|---|---|
| Hours of work a week | 36¾ |
| Vacation allowance, 24 working days of 6¾ hours, and all legal holidays | |

## Conclusion

The above tables show that the average attendance of the Museum is about 200,000 persons a year. This is an excellent attendance in a city with a population of about 118,000. The Museum is open on the average 2500 hours a year. The average visitor spends two hours in a visit in the Museum, and may make several visits in the course of the year. More than 200 groups of school children, averaging annually about 6000 pupils, are included in the total, and about 600 students of college grade. The public lectures by the staff reached during the current fiscal year about 9000 persons.

If we calculate the value of these visits at the rate of commercial recreation or educational recreation at 25 cents an hour, and allow an average of two hours for a Museum visit for 200,000 visitors, we have 400,000 hours of attendance, which at 25 cents per hour make $100,000 worth of educational recreation a year furnished the public free. If this is calculated at 50 cents an hour the amount is $200,000 and this represents, of course, only a part of the activities of the Museum. Yet this amount is about three times the amount of the total appropriation made each year (about $70,000) for the Museum.

## NEEDS OF THE MUSEUM

*The New Museum Building.* The preceding sections of this report have told of the present status of the Museum but has not attempted the broader orientation of the Museum and its relation of the State as a whole, or plans for its future. The people of New York State are now becoming conscious that the State Government can not keep pace with the tremendous development of the State as a whole unless it looks ahead for several years and plans definitely for the future. State planning for parks, highways and schools should also involve state education and research, as conducted by the State Museum. In providing an adequate office building at Albany for the State Government, Governor Alfred E. Smith realizes the crowded condition in the Education Building and has repeatedly advocated in public a new State Museum Building.

Such a building should provide ample space for exhibiting all phases of the natural resources and history of the State, many of which are today inadequately or wholly unrepresented in the exhibits of the Museum. As a rule well-lighted offices and laboratories and ample storage space are generally neglected in museums, and yet they are of major importance. Ample space should also be made to house the accumulations of historic and industrial materials. Vaults should provide space for the more valuable scientific and historic documents and objects.

*Other Needs of the Museum.* In addition to the proposed new building the following require emphasis:

1 Adequate *salaries* for the staff, and *increases* in their number. The leading staff positions should, as soon as possible, be placed on at least a $5000 basis. Corresponding positions elsewhere are paying considerably more.

2 Additional funds are needed for *printing* to clear up long standing obligations, and to build up a series of popular and scientific publications helpful to the schools and industries of the State.

3 Temporary fire proof *storage space* to make safe the accumulating collections until the proposed new building is built.

4 Acquirement in trust of *land and endowment* for the establishment and maintenance of *scientific and educational reservations* as out-door museums and for research in the field under controlled conditions.

# LIST OF MUSEUM ACCESSIONS FROM JANUARY 1, 1926–JULY 1, 1927

Accessions are new additions to the Museum. These are classified into the following groups:

1 By gifts; objects presented to the Museum

2 By exchange; for other Museum materials etc.

3 By purchase; payment from the Museum budget

4 By the staff; collected by the staff during official duties of any kind

5 By transfer, from other state departments, from within the Education Department, or from other divisions of the State Government, as provided by law

**By Donation**

Alexander, William P., Buffalo, N. Y.
  Collection of reptiles, batrachians and fishes, Allegany State Park, N. Y.
Allen, R. B., Fulton, Ky.
  Maple galls, Fulton, Ky.
Allis, Lewis, Milwaukee, Wis.
  Oak galls, Milwaukee, Wis.
Ambler, Mrs Silas P., Central Nassau, N. Y.
  Hand-made wooden cheese press
  Shoemaker's bench and shoe lasts
  Wooden flail. All from Central Nassau, N. Y.
Armstrong, N. M., Poughkeepsie, N. Y.
  Japanese beetles, Purchase, N. Y.
Arnold, Benjamin W., Albany, N. Y.
  2 Gastropods, Manitoulin Isle, Can.
Balk, Robert, New York City
  4 Fossils, Dutchess county, N. Y.
Blanchard, F. N., Ann Arbor, Mich.
  3 Amphibians, Louisiana
  Slimy Salamander, Alabama
Breunich, B., jr, North Pelham, N. Y.
  Oriental beetle grubs, North Pelham, N. Y.
Britten, W. F., Stillwater, N. Y.
  Aphids on Norway maple, Stillwater, N. Y.
Brown, Clair A., Albany, N. Y.
  2 Amphibians, Mount Rafinesque, N. Y.
Brown, Clark, Albany, N. Y.
  2 Cryptozoons, Saratoga, N. Y.
Burrell, A. B., Peru, N. Y.
  Fir saw-fly larvae, Peru, N. Y.
Bush, C. W., Utica, N. Y.
  Lined corn borer larvae, Utica, N. Y.
Chicago Crucible Company, through W. MacFadden, Chicago, Ill.
  2 Graphite crucibles, Chicago, Ill.
Cleaves, H. H., Albany, N. Y.
  Granite, South Mountain, Ga.
  2 Amphibians, Colorado
  White-footed mouse, Colorado
Commission for Relief in Belgium, through C. R. Richards, New York City
  2 Belgian medals
  Belgian war orphans plaque

Cooper, G. A., Hamilton, N. Y.
13 Crinoids, Hamilton, N. Y.
Countryman, Edward, Buffalo, N. Y.
3 Snakes, Allegany State Park, N. Y.
Cutler, George, Champlain, N. Y.
Polished ornamental malachite
Dietrich, H., Appleton, N. Y.
Collection of beetles, Appleton, N. Y.
Eaton, E. H., Geneva, N. Y.
Rattlesnake, Honeoye Lake, N. Y.
Ferguson, W. C., Hempstead, N. Y.
158 Plants, Long Island, N. Y.
Foerste, August F., Dayton, Ohio
82 Brachiopods, Kentucky, Indiana and Ohio
Fornonzini, Gervaso, Valtellina, Lanzada, Italy
2 Minerals, Valmalenco Valley, Italy
Frierson, L. S., Gayle, La.
Texas salamander, Louisiana
Gates, Elias, Coxsackie, N. Y.
Grooved ax, Keokuk, Iowa
Gilman, E., Cornwall, N. Y.
European hornet work, Cornwall, N. Y.
Giovanoli, Leonard, Lexington, Ky.
Mudpuppy, Kentucky
Gregory, H. B., Arden, N. Y.
Live wildcat, Arden, N. Y.
Hall, W. J., Troy, N. Y.
35 Archeological specimens, Watertown, N. Y.
Hancock, Richard, Birmingham, Eng.
Aquatic spiders, Birmingham, Eng.
Hecht, Helen, Saratoga Lake, N. Y.
2 Fish, Saratoga Lake, N. Y.
Hippisley, Mrs W. W., Terrace, B. C.
Spiraea galls, Terrace, B. C.
Hofmayr, John, Buffalo, N. Y.
2 Amphibians, Allegany State Park, N. Y.
Holligan, Edward, Albany, N. Y.
Star-nosed mole, Albany, N. Y.
Hopkins, A. S., Long Island, N. Y.
Spider, Babylon, Long Island, N. Y.
Horsey, R. E., Rochester, N. Y.
Larch case bearers
Wood-boring grubs
Rhododendron borer work
House, H. D., Albany, N. Y.
Painted turtle, Albany, N. Y.
Huested, P. L., Blauvelt, N. Y.
Box midge galls and larvae, Blauvelt, N. Y.
Ives, J. D., Jefferson City, Tenn.
3 Amphibians, Tennessee
Jacobs, J. V., Round Lake, N. Y.
Spring canker worms, Round Lake, N. Y.
Johnson, F., Albany, N. Y.
Hog-nosed snake, Albany, N. Y.
Klauber, L. M., San Diego, Calif.
California newt, California
Knobel, L., Hope, Ark.
Spiders, Hope, Ark.
Larchmont Greenhouses, Mamaroneck, N. Y.
Specimens of greenhouse leaf tyer, Mamaroneck, N. Y.
Mackey, R. W., Millerton, N. Y.
Rattlesnake, Millerton, N. Y.

MacClelland, Kenneth, Pawling, N. Y.
Skull of wildcat, Pawling, N. Y.
Martin, Mrs Carmelita, Worthington, Mass. (through William F. Jacob, Schenectady, N. Y.)
Framed picture of Joseph Henry's birthplace at Albany, N. Y.
Mastiske, Conrad, Albany, N. Y.
Musk turtle, Kinderhook Lake, N. Y.
Miller, E. S., Wading River, N. Y.
Golden tortoise beetle, Wading River, N. Y.
Moore, Emmeline, Albany, N. Y.
Pirate perch, Babylon lake, Long Island, N. Y.
Myers, Charles, Watervliet, N. Y.
Muskrat, Schuyler brook, N. Y.
Newland, D. H., Menands, N. Y.
Zircon, Indiahoma, Okla.
Paladin, Arthur, Albany, N. Y.
Gray fox skull, Karners, N. Y.
Raccoon skull, Stuyvesant, N. Y.
Palmer, Walter L., Albany, N. Y.
Specimen of meerschaum
Parkes, W. A., Toronto, Canada
Serpulites, Craigleth, Ontario, Can.
Patio, R., Malone, N. Y.
White-footed mouse, Malone, N. Y.
Patterson, J. H., Albany, N. Y.
Moss agate, Sidney, Mont.
Peirson, H. B., Augusta, Me.
Balsam galls, Augusta, Me.
Peltz, John DeWitt (Estate), Albany, N. Y.
66 Ethnological and archeological articles, Colorado, New Mexico (Received for disposition and donated to the Santa Fé Museum, New Mexico)
Perkins, Anne E., Collins, N. Y.
160 Plants, Erie county, N. Y.
Phelps, Mrs Orra Parker, Saratoga, N. Y.
250 Plants, St Lawrence, Saratoga and Warren counties, N. Y.
Hog-nosed snake, Saratoga, N. Y.
2 Mammals, Wilton, N. Y.
2 Mammals, Saratoga, N. Y.
Pollard, Ray T., Cobleskill, N. Y.
Striped corn borer larvae, Cobleskill, N. Y.
Potter, Catherine E. B., Whitehall, N. Y.
Collection of Spanish War and battleship "Maine" relics, made by Rear Admiral Potter; five Zulu spears, Africa
Reid, Alan, Troy, N. Y.
Garnet crystals, Horicon, N. Y.
Richardson, C. H., Syracuse, N. Y.
Ordovician limestone slab, Cavendish, N. Y.
Rogers, John, Albany, N. Y.
Cephalopod, New Salem, N. Y.
Ruedemann, Paul, Tulsa, Oklahoma
Graptolites, Ouatchita mountains, Oklahoma
Schaeffer, Charles, Brooklyn, N. Y.
West Indian peach scale, Brooklyn, N. Y.
Schillinger, Roy, New Lebanon, N. Y.
Milk snake, Lebanon Springs, N. Y.
Schoene, W. J., Blacksburg, Va.
European hornet work, Blacksburg, Va.
Schoonmaker, Mrs W., Rensselaer, N. Y.
House mouse, Rensselaer, N. Y.
Seaver, Fred J., Bronx Park, N. Y.
Japanese beetles, Bronx Park, N. Y.

Smith, Burnett, Syracuse, N. Y.
Fossil bear skull, Syracuse, N. Y.
Tooth of Casteroider, Syracuse, N. Y.
Smith, Ellsworth, Larchmont, N. Y.
West Indian peach scale, Larchmont, N. Y.
Spingern, J. E., Amenia, N. Y.
Larvae and work of willow leaf beetle, Amenia, N. Y.
Stein, W., Albany, N. Y.
Millipede, Selkirk, N. Y.
Stene, A. E., Kingston, R. I.
Juniper webworm work, Kingston, R. I.
Stevens, R., Greenwich, N. Y.
Wheat wireworm larvae, Greenwich, N. Y.
Stoneman, B., Albany, N. Y.
3 Archeological specimens, Texas
Stoneman, John E., Albany, N. Y.
Copper, Jerome, Ariz.
Gold, Stanton, Ariz.
Sweet, R., Troy, N. Y.
Ring-necked snake, Eagle Mills, N. Y.
Thacher, Mrs John Boyd (Estate), Albany, N. Y.
4 Iroquois wampum belts
Hiawatha Belt
Washington Treaty Belt
Commemorating First Sight of Pale Faces
Commemorating Champlain's Visit in 1609
Tiffany, R. W., Cambridge, N. Y.
Pyrite nodules, Cambridge, N. Y.
Tiffany, William J., Kings Park, N. Y.
Willow galls, Kings Park, N. Y.
Townsend, Frederick, Loudonville, N. Y.
Hog-nosed snake, Loudonville, N. Y.
Garter snake, Nassau, N. Y.
Tucker, Gilbert M., Albany, N. Y.
10 fragments of petrified trees, Holbrook, Ariz.
Audubon drawing of Crow, framed
Viereck, H. L., Washington, D. C.
Starling, Albany, N. Y.
Wagner, Clarence, Buffalo, N. Y.
3 Amphibians, Allegany State Park, N. Y.
Wagner, Ruth, Buffalo, N. Y.
Dusky salamander, Allegany State Park, N. Y.
Welcging, Richard, Schenectady, N. Y.
Fossil seaweed, Schenectady, N. Y.
Were, Arthur, Edna and Elizabeth, Albany, N. Y.
2 Ribbon snakes, Altamont, N. Y.
Spiders, Voorheesville and New Salem, N. Y.
Whiteford, M. W., Keeseville, N. Y.
Boulder and brachiopods, Keeseville, N. Y.
Williams, Homer B., Granville, N. Y.
2 Slabs Lower Cambrian slate, Granville, N. Y.
Woman's Roosevelt Memorial Association, New York City (Through Regent Charles B. Alexander, New York City)
Theodore Roosevelt medal
Young, Ruth, Slingerlands, N. Y.
Star-nosed mole, Slingerlands, N. Y.

**By Exchange**

Belanski, C., Nora Springs, Iowa
240 Devonian fossils, Iowa
Cornell University, Ithaca, N. Y.
9 Mammals, McLean, N. Y.

10 Mammals, Ithaca, N. Y.
2 Mammals, Cayuta Gorge, N. Y.
Gray squirrel, Danby, N. Y.
Florin, Rudolph, Stockholm, Sweden
6 Devonian fossil plants, Bear Island, Sweden
2 Devonian fossil plants, Norway, Sweden
Gortani, M., Bologna, Italy
53 Silurian graptolites, Sardinia, Italy
McKelvey, Robert, Saratoga, N. Y.
Quartz, Griqualand West, South Africa
Manck, E., Plauen, Saxony, Germany
12 Silurian graptolites, Saxony, Germany
National Museum, Washington, D. C.
62 Devonian fossils, West Virginia, Pennsylvania, Maryland
Train, Percy, Rochester, N. Y.
12 Triassic fossils, American Canon, Nevada
Troedsson, Gustaf, Stockholm, Sweden
19 Graptolites, Sweden

### By Purchase

Fletcher, Lewis D., Newburgh, N. Y.
Eskimo curlew
2 Passenger pigeons
Reinhard, E., Buffalo, N. Y.
12 Fossils, Ohio and New York
6 Fossils, Buffalo, N. Y.
Roof, Mrs Arthur B., Cannonsville, N. Y.
Cast of rill channels, Cannonsville, N. Y.

### By Museum Staff

Adams, Charles C., Albany, N. Y.
Celt, Howland Island, N. Y.
Alexander, W. P., and House, H. D.
1170 Plants, Allegany State Park, N. Y.
Bishop, S. C., Albany, N. Y.
Black snake and eggs, Albany, N. Y.
Pickerel frog, Albany, N. Y.
18 Reptiles, amphibians and eggs, Allegany State Park, N. Y.
Garter snake, Tennessee
Rattlesnake, Honeoye Lake, N. Y.
Hellbender, Allegheny River, N. Y.
Collection of amphibians and reptiles, Tennessee and North Carolina
Fence swift, Tennessee
Five-lined skunk, North Carolina
2 Fish, Allegany State Park, N. Y.
2 Mammals, Allegany State Park, N. Y.
Collection of spiders, New York, Tennessee, Georgia, North Carolina
Brown, C. A., Albany, N. Y.
230 Plants, Albany, Rensselaer, Greene counties, N. Y.
Chadwick, G. H.
Crustaceans and worms, Catskill, N. Y.
Chamberlin, K. F.
950 specimens of insects, largely from the vicinity of Albany
Clarke, N. T.
2 Snapping turtles and eggs, Lake George, N. Y.
Felt, E. P., Albany, N. Y.
3050 specimens of insects, largely from the vicinity of Albany
Goldring, Winifred, Albany, N. Y.
13 Upper Devonian plants, Gilboa, N. Y.
Ring-necked snake, Slingerlands, N. Y.
Planarian, Slingerlands, N. Y.

Harper, Francis
  Collection of mammals, Essex county, N. Y.
  Collection of mammals, Indian Lake, N. Y.
Hartnagel, C. A., Albany, N. Y.
  Canajoharie shale slab and graptolites, Fort Ticonderoga, N. Y.
Hotchkiss, Neil, Albany, N. Y.
  75 Plants, Albany, Rensselaer, Onondaga, Delaware counties, N. Y.
  200 Plants, Lewis county, N. Y.
House, H. D., Albany, N. Y.
  1373 Plants, 13 New York counties
Kilfoyle, C., Albany, N. Y.
  28 Graptolites, Tea Falls, N. Y.
  23 Fossils, Rensselaer, N. Y.
  4 Graptolites, Crescent, N. Y.
Ruedemann, Rudolf, Albany, N. Y.
  72 Graptolites, Stringtown, Okla.
  4 Fossils, Limestone Gap, Okla.
Schoonmaker, W. J., Albany, N. Y.
  Mountain salamander, Catskill, N. Y.
  3 Amphibians, Albany, N. Y.
  2 Amphibians, Stamford, N. Y.
  Eggs of tiger salamander, Syosset, N. Y.
  Mudpuppy, Quaker Run, N. Y.
  Hellbender, Allegheny river, N. Y.
  Slimy salamander, Allegany State Park, N. Y.
  Red-backed salamander, Malden Bridge, N. Y.
  Sheep's head, Lake Champlain, N. Y.
  2 Fish, Allegany State Park, N. Y.
  6 Mammals, Allegany State Park, N. Y.
  6 Mammals, Essex county, N. Y.
  Cotton tail, Burden lake, N. Y.
  Collection of woodchucks, Rensselaer county, N. Y.
Shaw, William T., Albany, N. Y.
  Collection of mammals, Rensselaer county, N. Y.

### By Transfer

Conservation Commission, Albany, N. Y.
  Blue-spotted sunfish, Greenwood lake, N. Y.
  Pickerel, Hudson run, N. Y.

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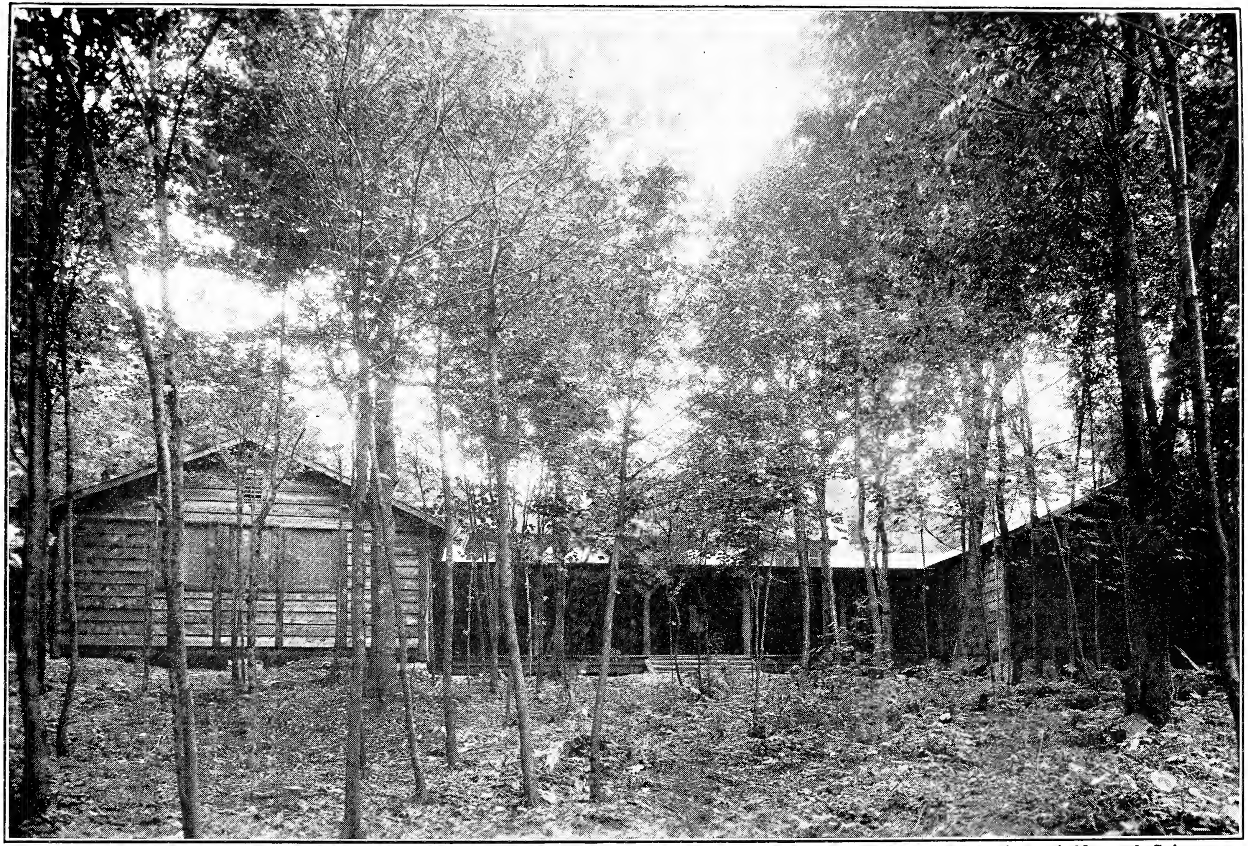

*Photo by Schneckenburger, courtesy of Buffalo Society of Natural Sciences*

Figure 2 Field laboratory used by the research staff of State Museum working at the Allegany School of Natural History in the Allegany State Park

*Photo by Schneckenburger, courtesy of Buffalo Society of Natural Sciences*

Figure 3 Research and educational staff of the Allegany School of Natural History in the Allegany State Park

*Photo by Schneckenburger, courtesy of Buffalo Society of Natural Sciences*

Figure 4 Type of cabin furnished the research staff working on surveys in the Allegany State Park region

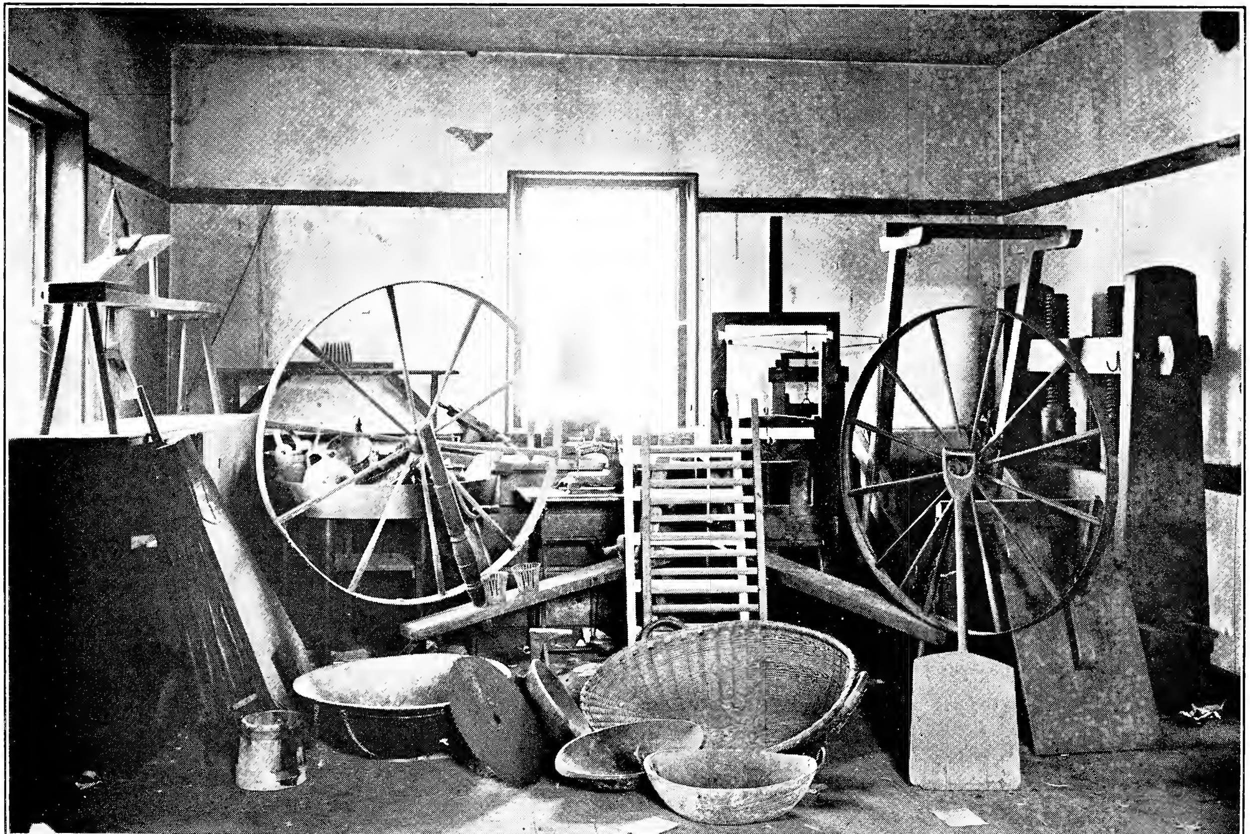

*Photo by Stein*

Figure 5 A part of the historical collection of household and industrial materials, secured for the State Museum from the original American Shaker settlement near Albany, N. Y.

# THE IMPORTANCE OF PRESERVING WILDERNESS CONDITIONS

By Charles C. Adams Ph.D., D.Sc.

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## INTRODUCTION

The subject of the preservation of areas in a natural or wilderness condition has been discussed more during the past ten years than during all of our previous history. The reason is that with our increased population we are becoming definitely conscious of the limitations of our natural resources. As long as these resources were considered boundless and inexhaustible we drifted along with the unconcern of children at play. Now we are beginning to realize that this problem is a phase of the fundamental relation of the people to the national resources of the country, or a phase of the "land problem." With the exception of the very arid regions, most wild land is in forests and therefore special attention is given to the foresters' point of view. Foresters began the study of their problem as an economic one, as a part of the general conservation movement, and are now just beginning to see that grazing and wild life are also a part of their problem, and are becoming conscious of the social aspects of the whole conservation movement. This realization has recently been brought about through an appreciation of the recreational and educational phases of the movement; which are distinctly social rather than economic. The earlier development of forestry so strongly imbued the profession as a group with economic standards and ideals that many are wholly unprepared for the next advance, which is almost certain to be strongly social. Later we may expect to see these two phases properly balanced both in theory and in practice, but many preliminary adjustments are yet to be made before the broader aspects of the problem are likely to be adequately appreciated. Certain conservatives are now preaching the dire results of the recreational wave, and of the menace threatening "economic" forestry from a too extensive development of parks. Future leaders should take a broader and possibly a "higher view" of the whole problem.

This dominance by economic standards of forestry has tended to make the forester desire to cut over, graze or change in some way nearly everything under his control, except where he dared not, as

in the case of protection forests. The value of virgin wilderness conditions for the study of forest ecology has not in the past received better recognition partly because forest research has been pushed aside by administrative emphasis. W. W. Ashe was a pioneer among foresters in advocating the preservation of natural conditions in forests for scientific and silvicultural purposes, and later Barrington Moore, through his interest in forest ecology, became a champion of the cause. Then Aldo Leopold enthusiastically urged the preservation of the wilderness from the standpoint of recreation and wild life. Great momentum is developing among other groups of leaders, not foresters, with whom a reckoning must be made if public interests are given a fair hearing. So much for the general background.

## WHAT IS A WILDERNESS CONDITION?

In the old days the idea of a condition of nature was not very carefully analyzed or understood. It was supposed to be a "balanced condition," and we were not very clear just what that meant. This often implied that independent of man's influence, nature was always "balanced," although modern ecology has taught us that in natural conditions, as in all others, this is a relative condition and not a fixed or absolute state; one that is a part of a cycle, involving a continuous process of change in response to all sorts of pressures and influences. The relative balancing of these various influences gives us the so-called balanced condition or a "dynamic equilibrium," which includes a summation of the larger and smaller units of dominance, which with every disturbance are followed by other changes.

Thus when ecologists emphasize the need of setting aside reservations for the preservation of natural conditions they do not mean, and certainly do not expect, the conditions to remain indefinitely "balanced," fixed and unchanged or unchanging, because they know that it is utterly impossible, both theoretically and practically, so to isolate a reservation from the rest of the world and keep it free from all outside influences.

Reservations set aside, however, *to allow nature to take her own course, with as little interference by man as is possible,* is quite another matter and is fundamentally all that is desired. To accomplish this is a very difficult undertaking.

## THE VARYING DEGREES OF THE WILDERNESS

As the degree of natural conditions is truly measured by its inverse relation to man's interference, we readily see why there are all degrees from natural conditions to the other extreme, such as metropolitan conditions where nature is crowded to the wall. On the one hand we have the different degrees of the destruction of natural conditions, and on the other hand, we have a whole series of conditions built up deliberately by man, all stages and degrees toward a *restored condition,* closely simulating natural conditions. We have known for ages that when man abandons the land it will "go back to nature" in a comparatively short time, depending of course on the character of man's interference, but this restoration is not the same thing as virgin or natural conditions. If this were true our problem would be much simpler than it is.

Urban conditions generally result in very great changes of natural conditions and the industrialized, residential and park uses of the land show many degrees of difference in the intensity of interference. The same is true of agricultural lands. The degrees from orchard and vineyard, grain fields, pastures to woodlots and mature forests likewise show many degrees. In the case of large forests, forested parks, game preserves and such uses of the land, we see relatively less disturbance with the natural conditions than in the more intensively cultivated areas. The cutting of a forest and the different systems of management will without question influence the ecological conditions for both plants and animals, but many of these changes are not so drastic, if fires are excluded, as to prevent the preservation of many plants and animals as long as the major habitats are preserved, as in the case where a continuous forest cover is maintained. In relative terms a woodlot is a wild area on a farm, and in the large state and federal forests there are remote areas which are today in a nearly or completely natural condition. Some of our national parks and some national monuments are in a relatively natural condition, but during the past few years the furore of advertising them and the efforts to get millions of persons into them—before an adequate staff and appropriations are available to handle the crowds—as well as certain policies, such as the introduction of exotic plants and animals and grazing, have caused very serious injury to many of these parks. As the public is taught the significance of these facts we hope that conditions will be remedied, because our national parks have given to the world a

new and valuable idea and ideal of land use. This conception is also having a beneficial influence upon forest policies, which have been too exclusively economic and very slightly social in their aims.

In the national and state forests we have a major opportunity for the preservation of excellent samples of natural conditions, since there are large areas that must be devoted to protection forests, and there are other large areas that will remain relatively natural for an indefinite period. Because of their remoteness some of these lands will long remain natural reservations in spite of economic policies.

In the national forests lumbering, grazing and particularly the extensive overgrazing have a blighting influence upon the natural conditions of the vegetation, and with poison weed control, reseeding, planting and similar methods the perpetuation of natural conditions becomes very serious indeed. Grazing animals compete directly with the large game animals in many places, not merely for forage and browse but also for water.

## THE VALUE OF THE WILDERNESS

The value of the wilderness must be judged ultimately by its contributions to social welfare. We have no better criterion. What therefore are some of the benefits? First of all let us turn to our own history for a few suggestions. Our American public first learned of natural conditions during its pioneer history. Historians have shown us how much our American democratic institutions have been a direct outgrowth of our *pioneering,* and how this has tended to encourage independence, self-reliance and other traits which have contributed so much toward our institutions and our ideals. There is a whole literature built upon this phase of our national life. Without question this background and our public domain, out of which we could with relative ease set aside national parks and national forests, have been dominating influences in acquainting Americans with the charm of the wilderness. Our first and greatest champion of all this was John Muir, who exemplified the benefits derived from the appreciation of the wilderness. He was a naturalist, an artist, and from the wilderness he derived science, art, education, recreation, producing a literature which is a wonderful blend of all these. He thus exemplified the social uses of the wilderness at its best. This great contribution could not come from one dominated by economic ideals. A whole Nation is now becoming educated to the Muir ideal and, as has been said, this is one of America's large and original contributions to the use of the land, as a definite land policy. This is

a policy which has since spread to the Old World and seems destined to have a great future there.

We may briefly summarize the value of natural conditions under the following heads: artistic, scientific, educational, recreational and economic, bearing in mind, of course, that these groups grade imperceptibly into one another in various directions.

**Artistic.** The inspiration and ideals which the painter, the poet, the author and the artistic photographer get from the wilderness is a form of leadership which helps the average person, not so keenly gifted to see and appreciate the beauties and wonders of wild nature (Figures 6 and 7). Muir, Thomas Moran and J. C. Van Dyke have opened up a whole world of interest and beauty to thousands of travelers and stay-at-homes. Jens Jensen, the landscape architect, has long preached the need of preserving wilderness conditions for the inspiration of such leaders. A nation can afford to pay a high price for such leaders but they can thrive only in a favorable environment. Sanborn (The Personality of Thoreau, 1901, p. 5) has said, "When Emerson said to his young visitor that 'he was always looking out for new poets and orators, and was sure the new generation of young men would contain some,' Thoreau quaintly said that 'he had found one in the Concord woods—only it had feathers, and had never been to Harvard College; still it had a voice and an aerial inclination—and little more was needed.' 'Let us cage it,' said Emerson. 'That is the way the world always spoils its poets,' was Thoreau's characteristic reply."

**Scientific.** Too often science is looked upon solely as a tool for economic purposes and many overlook the esthetic and intellectual pleasure derived from its study. There is as keen pleasure of understanding a problem as there is in looking at a beautiful scene or picture. Science is also a recreation for many persons, and one that merits much greater attention than is customary these days. The practical advantage of science might seem to need little emphasis to foresters, since forestry depends so much upon biologic, economic and social science, and yet I am convinced that the lack of scientific research is today one of the major limiting factors in the advance of forestry, particularly on the side of forest ecology, including economic and social research. In forest ecology research conducted on wilderness conditions is needed to supplement controlled experimental studies. We need to study not only forests but as well the animals if we are to have a thorough grasp of the forest as a functional biotic community.

**Educational.** The educational value of wilderness areas, aside from its scientific value, is very comprehensive and far-reaching. This applies to the young and to adults, and covers esthetic, scientific, recreational, economic and social aspects. With the industrialization and urbanization of our people it becomes increasingly urgent that the problems of the rural world be presented to them in concrete form. Otherwise they will certainly lose contact and sympathy with such conditions. I anticipate that this will be one of the major problems of the forester during the next generation. Economists and sociologists are already warning us of the danger of over-industrialization, and of its menace to agriculture and forestry, because the rural and the urban problems should be properly balanced for the welfare of the people as a whole. The general public should be taught that wilderness areas are of such great educational value that they must be preserved, even if public use is rather severely restricted in the immediate utilization of such areas.

**Recreational.** First of all let us note that recreation is not necessarily synonymous with the Coney Island variety of amusement. Recreation as a psychological and physiological change has come to have a new meaning with the industrialization of our people. Monotonous and mechanical routine makes recreation not a luxury but a necessity to a vast number of people. We have come to look upon play not as a waste of time, but as a normal healthy function, and even in education it is a relatively new idea to grant that the play of children is to be encouraged and not simply to be tolerated.

A complete change from our customary routine is one of the most important elements in recreation. It is for this reason that wild areas have a particular charm for the city dweller, and the more complete the change the better, if one is trained to appreciate the difference and to take advantage of it. A virgin forest of huge trees has an appeal not found in cut-over lands. Of course, there are many who do not know the difference, but there are those who clearly do.

**Economic.** And lastly the economic value of the wilderness should not be overlooked. Not long ago there were objections to "locking up" the natural resources in the national parks: the forage, the water, the timber, the game etc., and envious eyes looked upon all these as really wasted. We have not yet outgrown all this, yet some of the neighbors of the national parks are now beginning to learn that these so-called locked-up resources bring more money into their region than their own wide open system. The wilderness has thus come to have an economic value, but if we had allowed the

economic interests to control (and they have too much influence even today), they would have ruined our national parks before we had learned to appreciate their value. This statement can not be repeated too often. We may safely predict that the value of these areas will increase in direct proportion to our being able to keep them steadily wild and virgin. These must be preserved even at the cost of a very severe struggle. The public should be taught that overcrowding, alienating and tampering with these wilderness areas will ruin them, and that this will ultimately destroy their economic value in most instances. The state parks and state forests must also face this same problem.

## METHODS OF PRESERVING NATURAL CONDITIONS

The best methods of preserving natural wilderness conditions are very difficult to accomplish and the importance of this subject is so great that every possible method should be utilized. At present the outstanding and most successful method has been to encourage the *ideal* which has been slowly developing for our national parks. To live up to that ideal—*to pass on to future generations natural conditions unimpaired*—is a very difficult undertaking. It can not be assured until an eager, intelligent public sentiment is developed to support trained public officials. We can not maintain this standard in overcrowded parks, with inadequately trained staffs, with the importation of exotic plants and animals, fish and game, and with inexpert control of predatory animals, the pollution of streams, grazing and the cutting of timber, or light burning, the excess of roads or even trails. Such measures can be stopped only when an informed public insist upon the maintenance of the ideal which has now been evolving for over 50 years. National monuments need a kind of care similar to that of the national parks.

It is very interesting to note that the Swiss have gone much beyond us in their methods of preservation of their smaller national parks. Thus Dr Carl Schröter has recently said:

Shooting, fishing, manuring, grazing and woodcutting are entirely prohibited. No flower nor twig may be gathered, no animal killed and no stone removed; even the fallen tree must remain untouched. Nature alone is dominant! No hotels are allowed to be erected, and, naturally, no routes for motor cars. The whole must conserve an alpine character. Camping and the lighting of fires is prohibited. How different are the American national parks! There, big hotels are erected, automobile routes are constructed, and camping, even fishing is allowed. The American national parks are pleasure resorts, our national park, a 'Nature Sanctuary!' (Jour. of Mammalogy, 8:350–51, 1927.)

Turning now to the national forests, we find there are vast areas of wilderness in them, probably exceeding in area that of all our national parks, which are approximately as virgin as the parks themselves. But the national forest ideal involves changing these virgin conditions as rapidly as cultural methods can reach their remote or inaccessible areas. The protection forests are not likely to be distributed greatly. In addition to the virgin areas, which should be preserved for the study of forest ecology in the broadest sense, there should be set aside, as advocated by Emerson Hough and Aldo Leopold, certain large areas as true wilderness. Hough, advocated the Kaibab Plateau, north of the Grand Canyon in Arizona, and Leopold favored the Gila region in New Mexico and a similar effort has been for the preservation of a tract in the Superior Forest in Minnesota. Certainly we have other suitable areas, of variable size, in Utah, Idaho, Colorado, Oregon and Washington, in addition to Alaska, and possibly in Canada, that merit similar attention. To accomplish these results, however, there will need to be considerable change in the attitude of many officials and foresters. The acreage usually suggested for such reservations has often been very small indeed, due in part no doubt to the fear of not getting a hearing at all if large areas were suggested, and possibly also to the influence of the example of small "sample plots," used in silviculture. These areas should be large enough to preserve fair samples of all the more important types of forest communities under varied conditions, and more attention should be paid in their selection to the welfare of the plants and animals than to administrative *convenience*. Smaller areas also have their value if properly selected.

In the state forests and parks there should be definite provision for the preservation of certain areas in a natural state (Figures 8 and 9). In the highly modified conditions of the East this is more difficult, although along the coasts and in swampy, sandy or rocky areas there are yet to be found many valuable sites. In the West, however, the problem is often simpler, except in the very fertile agricultural areas, where progress seems to be relatively the slowest.

Some persons are enthusiastic over the policy of the preserving of such reservations by private individuals, but few of such preserves survive more than two or three generations, and generally the second is the turning point.

While there has been considerable activity for the establishment of game preserves and bird reservations, the primary purpose subordinates natural conditions to certain game or to birds, and control measures destroy the natural conditions in varying degrees. Such organizations are not today a very hopeful source of aid for the preservation of natural conditions, because as a rule the special interest is so strong that they consider their interference negligible or desirable.

One of the most hopeful prospects for the preservation of natural conditions is in connection with various educational institutions and organizations, including museums. Several of our state universities have already acquired lands and water which they use for scientific purposes, and some such areas are being preserved in a wild state. Thus the University of Washington has a marine biological station and has made a preserve area as a part of it. The University of Montana has some lands on Flathead lake which have this possibility. The University of Illinois has a small reservation. Indiana University has a small tract. Cornell University has a wild flower preserve as well as the McLean Bog for this purpose. The New York State Museum, under the leadership of Dr John M. Clarke, acquired by gifts several valuable geological reservations, but funds were never available to protect the plants and animals on them. Yale University has recently acquired 200 acres for a preserve. It is not virgin but plans are being made to restore it. The University of North Carolina has a 950-acre wooded tract adjacent to the campus. Some of the western state universities own considerable land, and ought to be able to set aside valuable areas as wild preserves if a serious effort is made to do so, particularly in Minnesota with its state land.

In spite of the preceding remarks, the universities have been particularly backward in acquiring wild lands for both teaching and for research. Without such lands they are likely to lose touch with outdoor natural history, ecology and allied problems of conservation. It is largely in an indoor atmosphere that what Dr W. M. Wheeler of Harvard University called "academic dry rot" thrives, and biology can not afford to lose contact with the natural conditions of life. The same condition holds for museums. Only the largest metropolitan museums can hope to be world microcosms, and even these grow largely by their active field work and explorations. Smaller museums need to maintain a similar contact with the outer world

and direct active interest in carefully selected reservations and field survey in order to retard the growth of "dry rot" which at times infests other educational institutions. The advantage therefore of wild areas is not simply the opportunity for an occasional visitor and student to make some special study—as important as that is—but is the influence upon the workers themselves and their institutions. If our educational institutions do not have this advantage educational leadership in such matters will pass on to other better qualified leaders.

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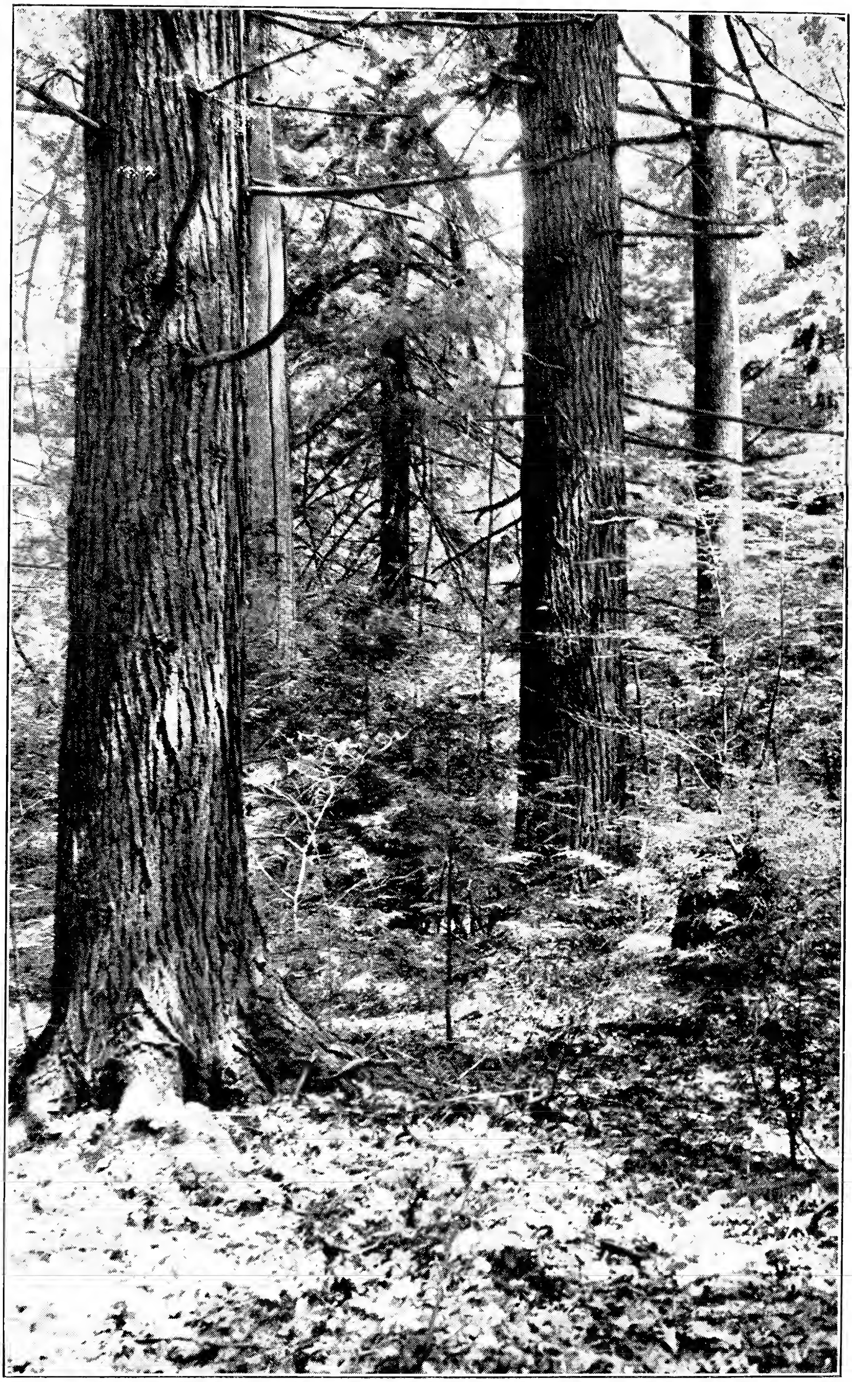
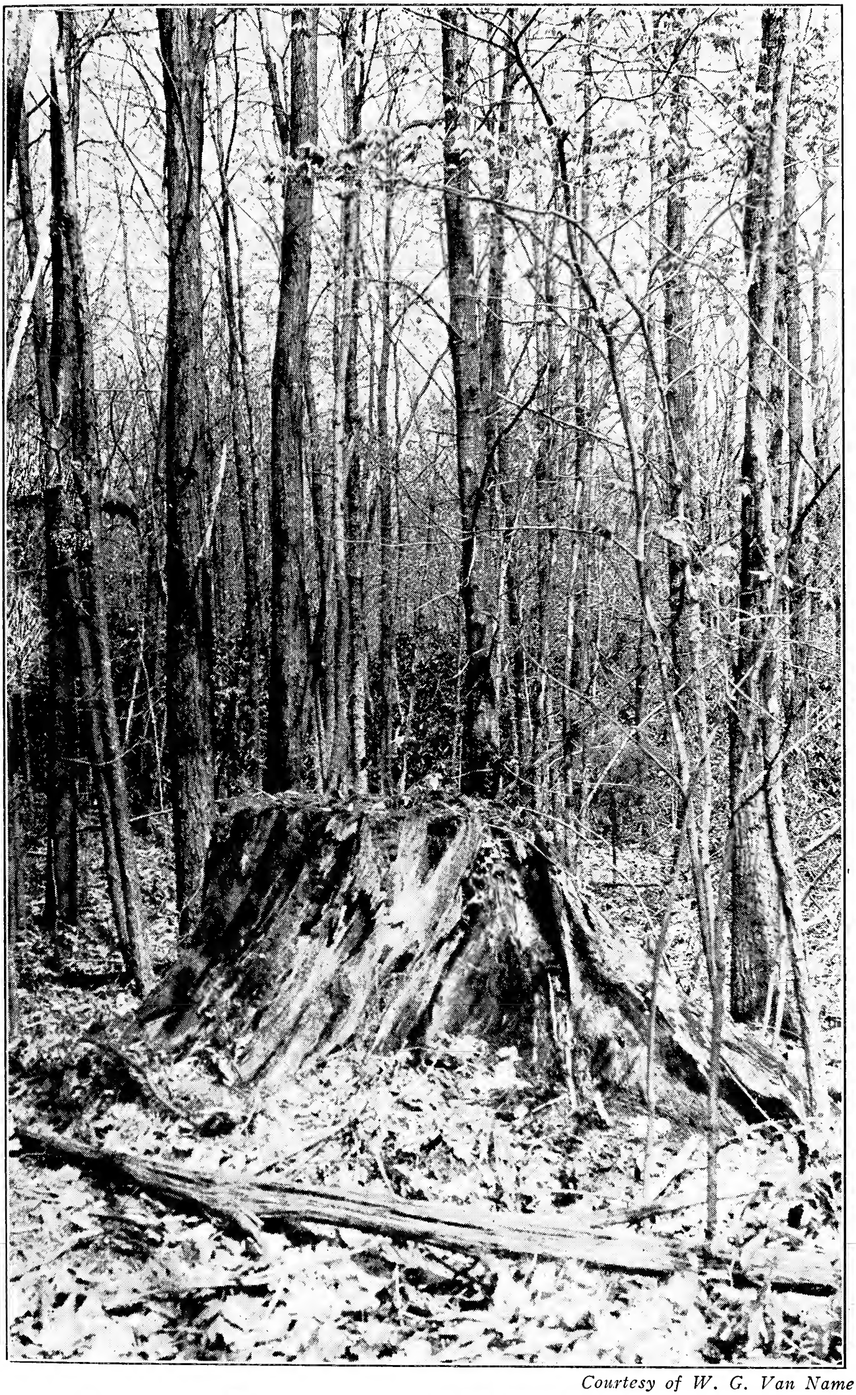


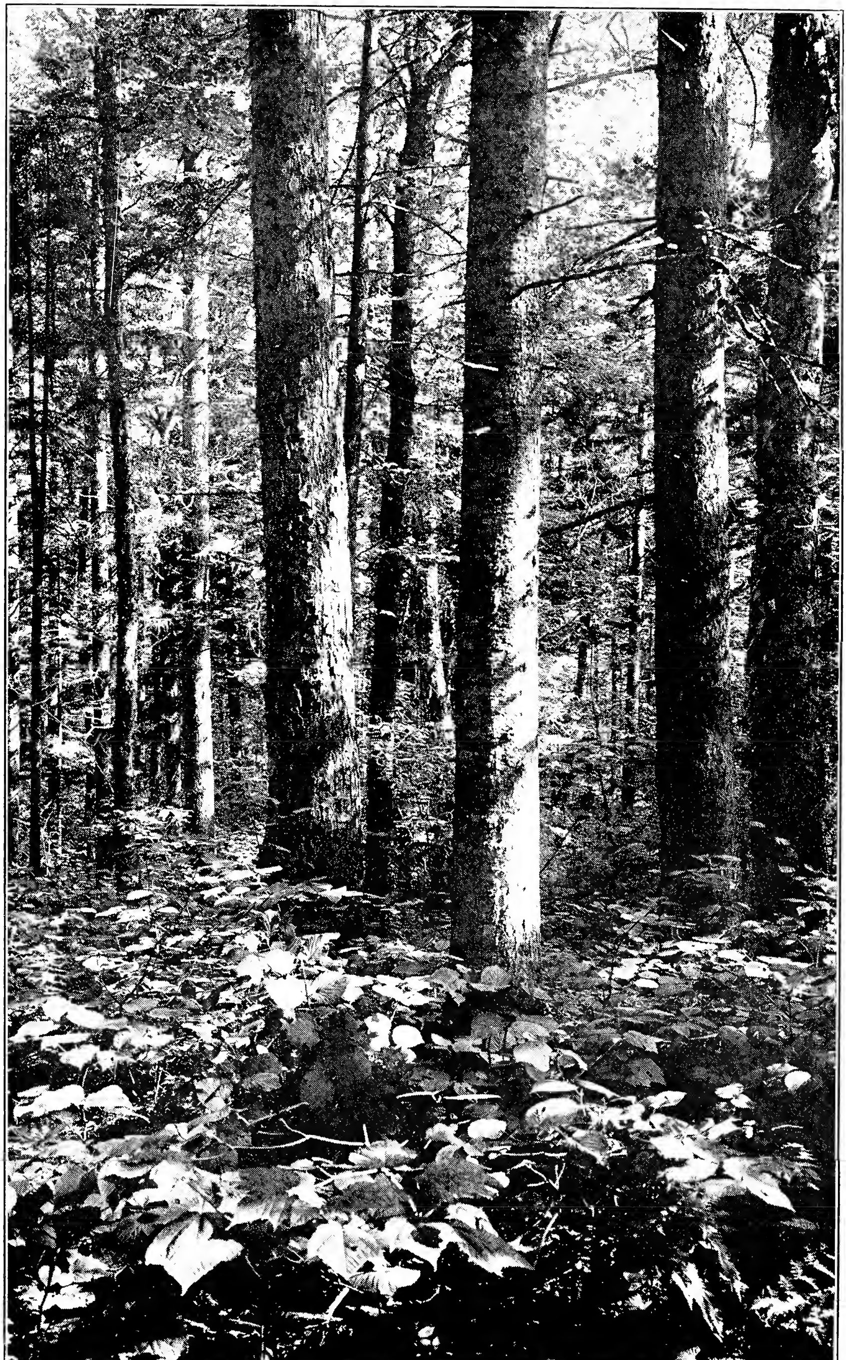
*Courtesy of W. G. Van Name*

Figure 6 Must we urge the preservation of such samples of virgin forests? There are other values as well as economic. The Cook Forest in western Pennsylvania.



*Courtesy of W. G. Van Name*

Figure 7 Or do we prefer this sort of forest; even a generation after cutting? Part of the Cook Forest in western Pennsylvania.



*Courtesy of N. Y. State Conservation Dep't*

Figure 8 Does New York State need to preserve *samples* of such forests? Virgin hardwoods on Seward mountain in the Adirondacks.

*Courtesy of New York State Conservation Dep't*

Figure 9 Another view in the Adirondacks. How long will it require to restore this?

## MAKING FOSSILS POPULAR IN THE STATE MUSEUM

By Rudolf Ruedemann and Winifred Goldring

*Paleontologists, New York State Museum, Albany, New York*

Popularizing fossils sounds simple enough until the work is actually undertaken. When the present State Museum was ready for the installation of exhibits the Hall of Invertebrate Paleontology was turned over to Doctor Ruedemann, now State Paleontologist. Very little had been done in the old Geological Hall (the former headquarters of the Museum) in the way of exhibiting fossils, so that Doctor Ruedemann had upon his hands the installation of an entirely new invertebrate exhibit. The various types of cases had been carefully chosen even before the Museum was ready. One type of case was used for the whole synoptic collection, and here maps showing the extent of the sea during the different periods, and also charts, each showing the outcrops of one formation with its different facies, were used to make the exhibits more intelligible. Exhibits of special groups, such as trilobites, eurypterids, crinoids etc., were displayed in another type of case. Wall cases were used to supplement the synoptic exhibit and also for special exhibits. Gradually still other types of cases were introduced as they were found necessary for particular displays. The aim throughout was to avoid monotony caused by too much sameness in the cases and to strive for the most interesting forms of display. Small and more technical labels were numerous, of course, but these were supplemented by larger explanatory labels of a more general nature. We tried to make an attractive and interesting exhibit of fossil material, and from comments made by scientists and others felt that we had succeeded rather well.

As time went on, however, from watching the persons who visited the Museum, we began to feel that we had perhaps catered too much to the scientists and those already with some training in or understanding of fossils. It was not very flattering to have a group of persons enter the Hall of Invertebrate Paleontology, give a quick look around, and say, "Let's go out; there is nothing but dead things in here." It was quite evident that we needed to increase our efforts to make our exhibits intelligible and interesting to the general public. Our fossils must be made to live. With this in mind restoration groups and explanatory cases are gradually being introduced among the fossil exhibits.

Of the latter kind are the two cases explaining "What is a Fossil?" planned by Miss Goldring to give the unscientific visitor a background which will permit him to study the fossil exhibits with more understanding. These cases stand near the entrance of the hall. A label with a full but simplified definition of a fossil is placed at the top of one case. This case shows examples of all the different ways in which a fossil may be preserved. Likewise in this case is a series of specimens showing various stages in fossilization from loose shells on a sea beach or river bank through loosely consolidated specimens to completely cemented fossil-bearing rocks. Examples of the effect of partial and complete weathering on fossil-bearing rocks are also shown. Clay concretions, often mistaken for fossils because of their odd shapes, likewise have their place here, as well as pseudo-fossils which are of inorganic nature — either stains from decaying vegetable matter or branching mineral incrustations often mistaken by the uninitiated for fossil mosses or ferns.

The second case has various illustrations of the preservation of organisms according to their original composition. Here are shown the effect of conditions of preservation upon the original form, also fragmentary preservation and the distortion of fossils by movements of the rock beds in which they are preserved. In this case belongs also the explanation of types, models, restorations, "squeezes" of various kinds, thin sections, natural and polished sections which are so often seen in fossil exhibit cases and not always comprehended.

It has been said that a museum should be a collection of labels illustrated by specimens; and that idea has been carried out in these cases. Very full explanatory labels accompany all the examples; but for those who wish to spend less time there are subheadings with the specimens, which with the full title label permit them to gain something from these cases with a quick survey.

The results obtained from these two cases have been very gratifying. They have attracted wide attention not only from the general public but also from scientific visitors. Because of the success of these cases, a similar exhibit has been installed in the new Peabody Museum at Yale University. Dr F. A. Bather of the British Museum was much impressed with the cases when he visited our Museum a couple of years ago and has since then written a short paper in which he points out the need for such a case in every museum.

Another educational case, "What is a Geological Formation?" has recently been installed by Miss Goldring as a companion to the "What is a Fossil?" exhibit. It has been placed near the entrance

to the Hall of Invertebrate Paleontology at the beginning of the series of synoptic cases, and has already attracted considerable attention.

The case was designed to give a better understanding of the meaning of a geologic formation. On top of the case is a title label giving a comprehensive and understandable definition of a geological formation, and in the case is a large, very full explanatory label. Six geologic maps of the State are shown. One map gives the surface distribution of the rocks of all the different ages. Each of the other five maps shows one of the important divisions: the present outcrop of the rocks of that age; the former extent of the rocks, which erosion has decreased; and the extension of these rocks southward under the younger beds. Five cross sections made through different parts of the State show the undersurface conditions: the relations of the beds of the different ages, their general slope and thickness. A geologic column is used to show in more detail the succession from the oldest to the youngest beds in the eastern and western areas.

A plate of drawings of a few characteristic fossils has been made for each age. The visitor is referred to the synoptic cases where are displayed the actual fossil specimens of these and other species, and also outcrop maps of the various formations and maps showing the configuration of North America at each stage.

Colored photographs of typical exposures of the rocks of the different formations add to the attractiveness and instructive value of this case. These photographs are colored in oil so that there is no danger of fading. The Museum draftsman, E. J. Stein, has made a specialty of this oil coloring.

Some restorations in plaster were used from the first in the Museum. More were introduced when we began to see how important they were in giving a better understanding of our fossils; and then came our wax restoration groups which have attracted such wide attention. With the exception of the Devonian Forest restoration, all the restorations and restoration groups were to a greater or less extent planned by Doctor Ruedemann and he supervised the work of the artist and sculptor, Henri Marchand. The plaster restorations include life-sized models of eurypterids (*Eusarcus, Stylonurus* and *Pterygotus*), life-sized models of *Crustaceans* (*Mesothyra, Lichas, Homalonotus* and *Dalmanites*), models of growth stages of four species of eurypterids (*Hughmilleria shawangunk* Clarke, *Eurypterus maria* Clarke, *Stylonurus myops* Clarke and *Pterygotus globiceps* C. & R.) modeled by Doctor Ruedemann himself, and models illustrating the internal structure of the shells of cephalopods—also made

by him. Doctor Ruedemann was not quite satisfied with the effect of the plaster models, and, to see if he could get them to look more lifelike, had one or two painted in natural colors by G. S. Barkentin, draftsman at the time, who was very clever at this kind of work. The results more than fulfilled expectations and all the models were treated in this way.

The Eusarcus Group was the first restoration group used in the Museum, and as this was at a time when we were still in the plaster stage, the two restorations of Eusarcus in this group are of plaster. The first restorations in wax made by Mr Marchand were the primitive fishes, *Bothriolepis* and *Cephalaspis,* that now form a small group in the Hall of Vertebrate Paleontology. These wax restorations were found so much more satisfactory than those in plaster that it was decided to continue to use them. A case showing the restoration of Portage life was the next to appear, then the restoration case showing Helderberg life, and finally the Upper Devonian Sponge case. It is planned to add to the restorations a Cambrian, Ordovician and Silurian case to complete our series of "period" cases. A crinoid case bringing together different types of Devonian crinoids, regardless of formation, just as was done in the case of the Upper Devonian sponges, to show the wealth of the New York Devonian rocks in these forms, was already discussed with the artist before the Devonian Forest group was started; and more of this type of case will be added as time and money and room permit.

In one of the graptolite cases fossils and restorations have been combined very effectively; and this idea could be well carried out with other groups. The slabs containing the graptolites are arranged at the bottom of the case, the floor of which is a very much flattened pyramid. Wax restorations of the most important generic groups shown on the slabs are suspended at various heights from the glass top of the case.

The latest, also the largest and most elaborate restoration undertaken by the Museum is the Upper Devonian (Gilboa) Forest group. This group has a width of about 36 feet, a depth from 16 to 18 feet, and a height around 25 to 30 feet. The restoration was executed by Henri Marchand and his two sons, Georges and Paul, under the supervision of Miss Goldring. In this group a new departure was made: in the foreground (idealized, of course) a reproduction of the actual conditions under which the fossil trees were found is shown; in the background a restoration of the forest as it might have appeared in the height of its glory. The two ideas have been successfully worked out and beautifully combined by

the artist. This group not only serves its purpose as a scientific reproduction but through the painting in the background, especially, deserves to be numbered among works of art.

Not all of the restoration cases were set up at once, as one continuous piece of work; but the groups were assembled piece by piece, as the Museum could afford it. Money was not always available, and the Museum owes much to the late Director, Dr John M. Clarke, for supporting these restorations and for his untiring efforts to obtain the money for them, if not from the State, then as gifts from private individuals. To carry out all our plans fully, we shall need the new State Museum which was the unfulfilled dream of our late Director.


Figure 10 First case illustrating "What is a Fossil?"

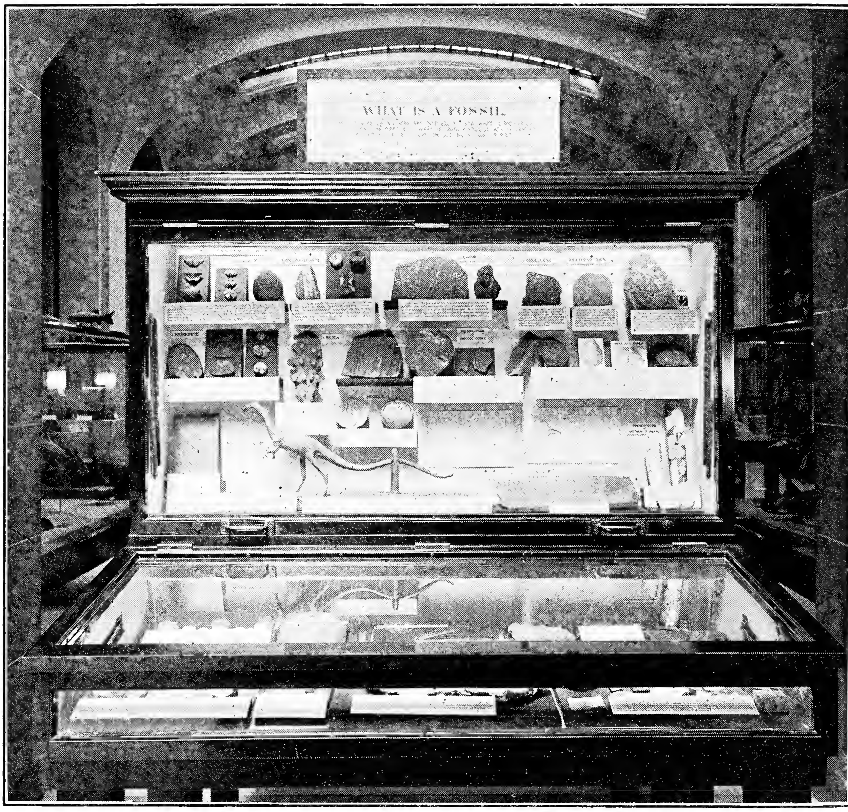



Figure 11 Second case illustrating "What is a Fossil?"


Figure 12 Rear and end view of case illustrating "What is a Geologic Formation?"


Figure 13 Case containing selected slabs with graptolites and restorations of graptolites in wax. When completed, it will show a phylogenetic series of the principal genera.

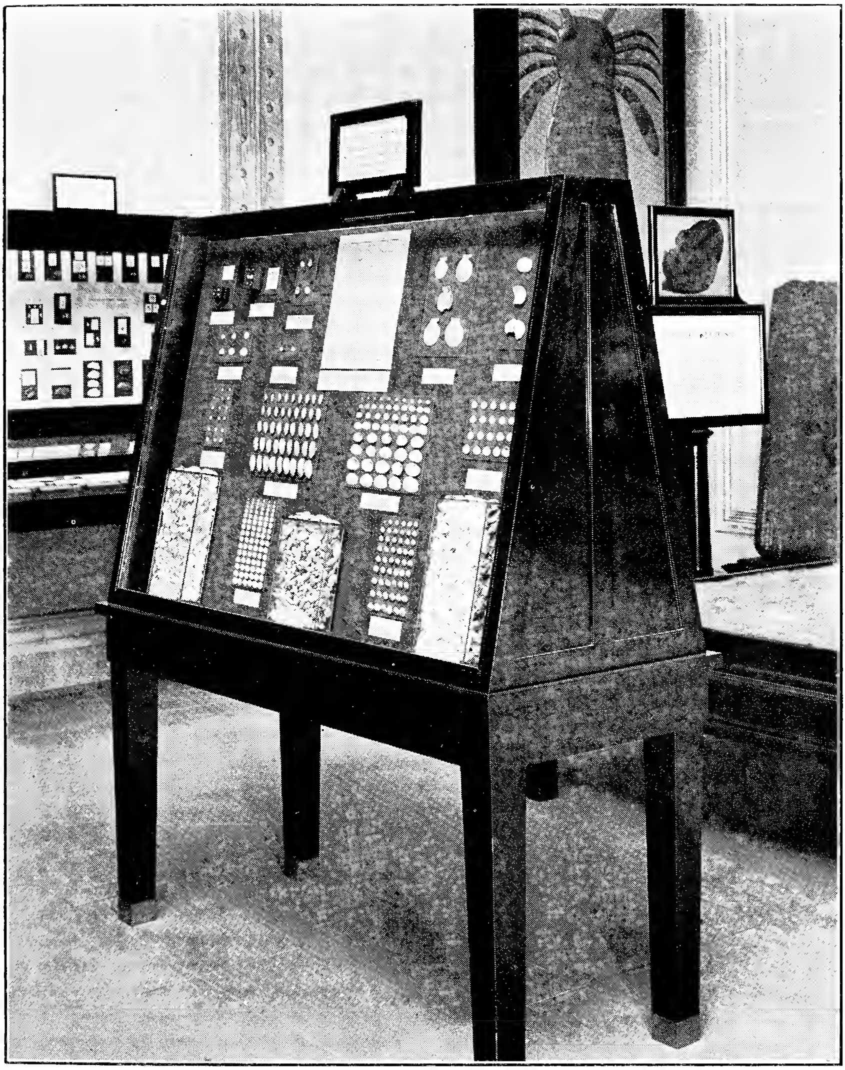


Figure 14 One side of a special exhibit case, illustrating the marine invasion of the post-glacial Champlain period in the Lake Champlain basin. Arranged by Miss Goldring.


Figure 15 The Gilboa Group, showing the rocks with the three horizons of fossil stumps in front, and the restoration of the forest in the background.

# THE THACHER WAMPUM BELTS OF THE NEW YORK STATE MUSEUM

By Noah T. Clarke

*Archeologist, New York State Museum*

With the accession of four rare Iroquois wampum belts that have been willed to the State of New York by Emma Treadwell Thacher, widow of John Boyd Thacher of Albany, the State Museum collection of wampum is now considered to excel any group of this nature in existence. Although there are larger collections, the wampum belts owned by the State are declared to be of greater historical value than those in any other collection.

In this connection it is recalled that at a council of the Onondaga Nation held on February 26, 1898, The University of the State of New York was elected wampum keeper of the Onondaga Nation with power "to get possession of and to safely keep forever all wampums of the Onondaga Nation and the Five Nations and Six Nations and each of them." At the same time a resolution was adopted stating that "the Onondaga Nation does hereby sell to The University of the State of New York all wampums for $500" and the University was made the "attorney in fact" of the Onondaga Nation to recover such wampums by suit or otherwise in the name of the Onondaga Nation or any of the subscribing chiefs or sachems.

The election to this office and the transfer of the wampum were confirmed by an action of the Board of Regents on March 22, 1898, and by an act of the Legislature in 1899. The actual transfer was made during appropriate exercises at the thirty-sixth annual Convocation of The University of the State of New York held in the Senate Chamber of the State Capitol, June 27–29, 1898.

The four wampum belts recently acquired by the State Museum are known as the Hiawatha Belt, the Washington Covenant Belt, the Wampum to Mark the First Sight of Pale Faces, and the Champlain Belt. These four belts were purchased by Mr Thacher for $500 on March 24, 1893. In 1890 when a census of the Indians of New York State was being taken under the direction of Colonel Henry B. Carrington of Hyde Park, Mass., he learned that these wampums were in the possession of Thomas Webster, an Onondaga Indian. Desiring to have them preserved in a safe place, Colonel Carrington obtained permission of Webster to dispose of them. Since the Federal Government would not purchase them, Colonel

Carrington bought them for himself. He later disposed of them to the Rev. Dr Oliver Crane of Boston who placed them on exhibition in the Boston Art Museum with the hope that they would be purchased by that institution. Lack of funds, however, prevented this. Declining to sell them to Yale University for $800, since he believed they should be in the possession of New York State, Doctor Crane permitted their exhibition by the State of New York at the Columbian Exposition. John Boyd Thacher and Senator Donald McNaughton were members of the Board of Commissioners in charge of the preparation of this exposition. Learning that there was no state appropriation for the purchase of the belts and desiring to have them exhibited, Mr Thacher personally purchased them.

The name "wampum" is a term which the early colonists derived from the Algonkian word "Wampompeag," meaning a string (of shell beads). Indians were attracted to the use of shells for personal adornment by their natural beauty. On account of their thin, sharp edges they were brought into service as implements and utensils such as cups, spoons, scrapers, digging tools and knives.

Shell beads were the handiwork of the women, whose skilful hands were accustomed to the delicate and tedious operation of their manufacture. Wampum beads are small cylindrical shell beads which measure about a quarter of an inch in length and one-eighth of an inch in diameter. They were wrought from various species of shells but those made in the eastern section of the United States were cut out from those found along the Atlantic sea coast, such as the common hard shell clam (*Venus mercenaria*); the periwinkle (*Pyrula carica* and *P. canaliculata*); the whelk (*Buccinum undatum*); and fresh-water shells of the genus Unio (Bureau of American Ethnology, Bulletin 30, pt. 2, p. 904). These afforded the manufacture of two-color varieties, the white being formed from the thicker portion of the shell and the dark, or purple bead, cut from the purple spot in the clam shell.

In trade, wampum was used either in strings or loose. When loose, they were counted out and six white beads equalled in value three of the dark ones or, according to one authority, the amount of one penny. Each dark bead therefore was worth twice the amount of the white. By the string, they were measured into strands of 360 white and 180 dark beads. These were known as "fathoms" and each "fathom" was valued at 60 cents in trade.

Shell beads, or wampum, besides their use as necklaces and for purposes of exchange, were used in strings in public transactions of various nature and significance. By stringing in different order or

color combinations, a definite idea or thought could be conveyed or recorded and this, in turn, could be interpreted without confusion. White beads in themselves when used in ritual or ceremony, conveyed the idea of peace, health and harmony; the dark or purple beads when used alone in ceremonies, denoted the idea of sorrow, death, mourning and hostility. White beads were sometimes dyed red to signify the declaration of war or used as an invitation to friends to join them in war.

The wampum belt was another product of these white and purple shell beads. These beads were strung on twisted threads made from the inner bark of the elm tree and fashioned into mats or belts by working parallel lines of beads over strips of buckskin wound with shreds of deer sinew. A variety of symbolic designs were thought out and incorporated in the manufacture of these belts as a means of recording important events, in the ratification of treaties and, in some cases, to guarantee proposals made by one people to another.

### Hiawatha Belt

One of the most important and valuable of these belts (Figure 16) in existence is the Iroquoian wampum belt known as the Hiawatha Belt received from Mrs Thacher's estate. This is in the form of a purple beaded mat 21½ inches long and 38 beads in width, or 10½ inches. A symbolic design in white beads has been worked in along its length and consists of four hollow squares on either side of a figure of a heart (tree) which occupies the center.

The belt itself is considered the original record of the formation of the Iroquois League, when representatives sat at the great council to ratify the Union of the Five Nations. The exact age of this belt is unknown, but Colonel Carrington has said that it is "the official memorial of the organization of the Iroquois Confederacy, relating back to the middle of the 16th century." The "reading" of this belt as made by Daniel and Thomas La Forte at Onondaga Castle July 19 and August 1, 1898, follows: "One heart of the Five Nations—that if any hurt of any one animal would pierce that heart then they would all feel it—all the Five Nations. This was in Hiawatha's belt. That they are a united people. This is the original Hiawatha belt—a record of the first agreement to make the League."

Under section 60 of the original Iroquois Code (Emblematical Union Compact) of the Great Binding Law, found in New York State Museum Bulletin 184, page 47, reference is made to the inter-

pretation of the designs on this belt. "The first of the squares on the left represents the Mohawk Nation and its territory; the second square on the left and the one near the heart, represents the Oneida Nation and its territory; the white heart in the middle represents the Onondaga Nation and its territory, and also means that the heart of the Five Nations is single in its loyalty to the Great Peace, that the Great Peace is lodged in the heart (meaning the Onondaga Confederate Lords), and that the Council Fire is to burn there for the Five Nations, and further, it means that the authority is given to advance the cause of peace whereby hostile nations out of the Confederacy shall cease warfare; the white square to the right of the heart represents the Cayuga Nation and its territory and the fourth and last square represents the Seneca Nation and its territory."

"White shall here symbolize that no evil or jealous thoughts shall creep into the minds of the Lords while in council under the Great Peace. White the emblem of peace, love, charity and equity surrounds and guards the Five Nations."

In reversing the belt, the figure of the "heart" in the center assumes the appearance of a tree and at the same time brings the geographical position of the Five Nations in the correct order on the belt. A figure of a tree might well represent the Onondaga Nation as the Onondagas were designated to keep the council fire and it was under the Great Tree of Light that the nations met in council.

## Washington Covenant Belt

Another most valuable and unique historical wampum belt (Figure 17) of the Thacher collection is that known as the Washington Covenant Belt. It is reputed to be unsurpassed in the excellence of its construction and it was the belt most highly prized by the wampum keepers of the Onondaga Nation. It is so called by reason of the fact that during the presidency of George Washington it was used as a covenant of peace between the 13 original states which he represented and the Six Nations of the Iroquois.

The belt measures 6 feet 3½ inches in length and has 15 rows of beads across its width, or 5¼ inches. It includes a total of about ten thousand beads. The symbolic figures of 15 men with outstretched arms and clasped hands extend along its length. In the center is a figure of a house, from the roof of which extends a projecting shelter for the two men standing on either side. These two figures may be considered to be the Keepers of the East and West Doors respectively of the Iroquoian Long House who are

acting as guards to the open door of the effigy of the pale face house, or the National Capitol Building. The other remaining 13 figures, signifying the 13 original colonies, are joined in unity by the clasped hands. The designs are woven in the dark or purple beads on a solid white beaded field which denotes peace and friendship.

### Wampum to Commemorate First Sight of Pale Faces

The third belt (Figure 18) in this collection is 28 inches long and 13 beads in width, or 3½ inches. It is woven on buckskin thongs with a white background bearing four groups of three purple beaded diagonal lines. It was made by the Iroquois to commemorate "the sight of the first pale faces." It is not known whether this refers to the first sight of Spaniards, French or Dutch. John Buck, who was an Onondaga chief and once wampum keeper, remarked that diagonal stripes across a belt were symbols of agreement that the tribe giving the belt would help the Six Nations in war. These were props, or supports, for the Long House; the symbol of the confederacy. In this sense the diagonal lines may be considered to signify the willingness of support to the whites by the Indians.

### Champlain Wampum Belt

The last belt (Figure 19) in this remarkable group is 39½ inches long and has seven rows of beads to form its width, 2 inches. It is practically a duplicate of one already in the State Museum collection. Both belts are woven with purple beaded backgrounds carrying a series of five white beaded circles across the length. At each end for a length of an inch are alternating rows of white and purple beads. The belt referred to as being in the State collection is known as the General Eli S. Parker belt and signifies the strength and unity of the Five Nations. As General Parker was a principal sachem (Rodiyanersooh) of the Senecas, he held this belt by right of his title. The "reading" of the Thacher belt as given by Daniel and Thomas La Forte at Onondaga Castle, July 19 and August 1, 1898, is as follows: "Represents a sorrow meeting of the Five Nations. If a misfortune happen: if little boys and girls were taken and one killed—to consider what should be done for remedy that misfortune—a tooth for a tooth, an eye for an eye. This is a Hiawatha Belt. This belt is used when meeting of that kind is called." A label on this belt states that it commemorates the excursion of Samuel Champlain into the country of the Iroquois in 1609.

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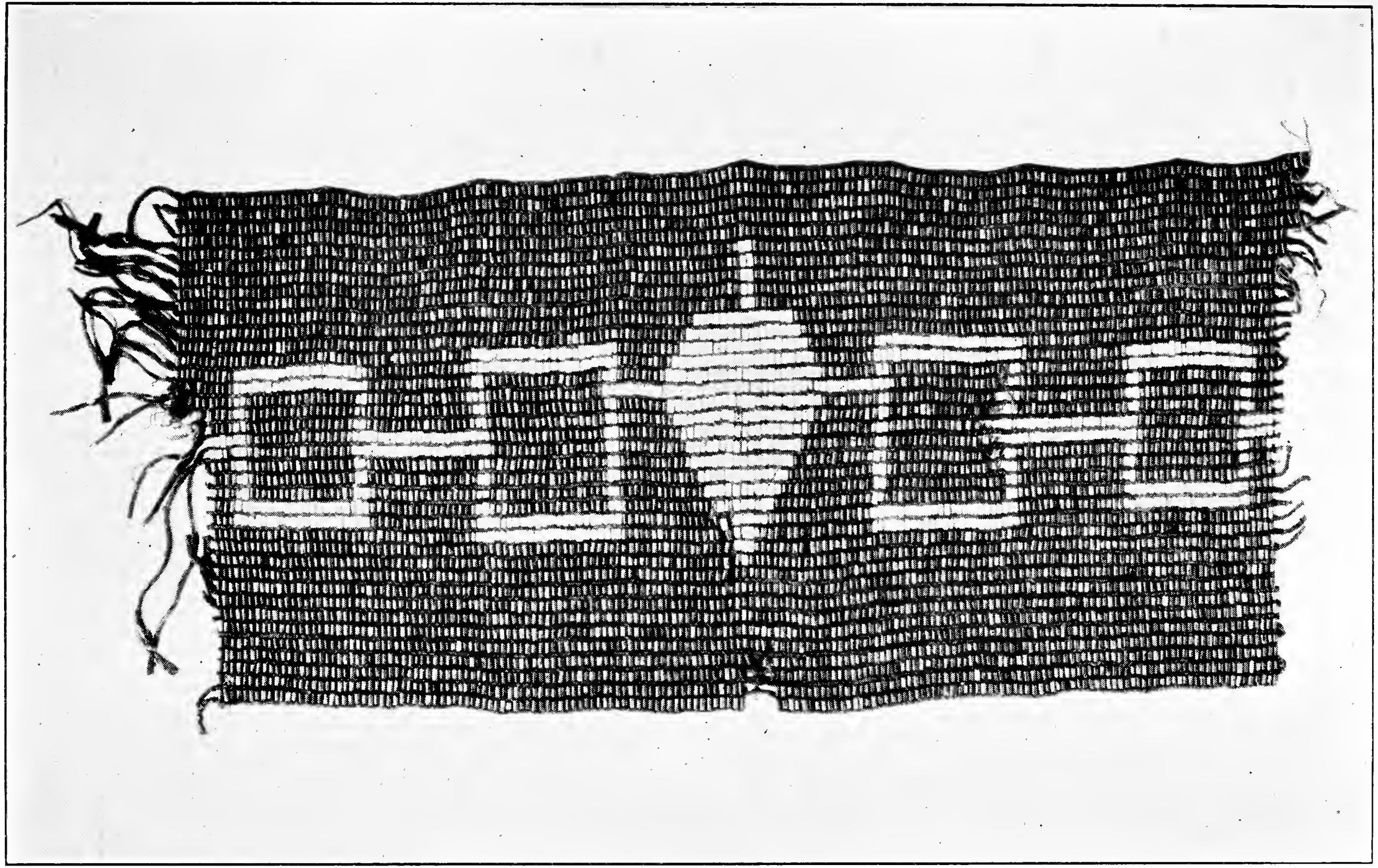

Figure 16 The Hiawatha Belt. Considered the original record of the Formation of the Iroquois League of the Five Nations. It is one of the most important and valuable wampum belts in existence.

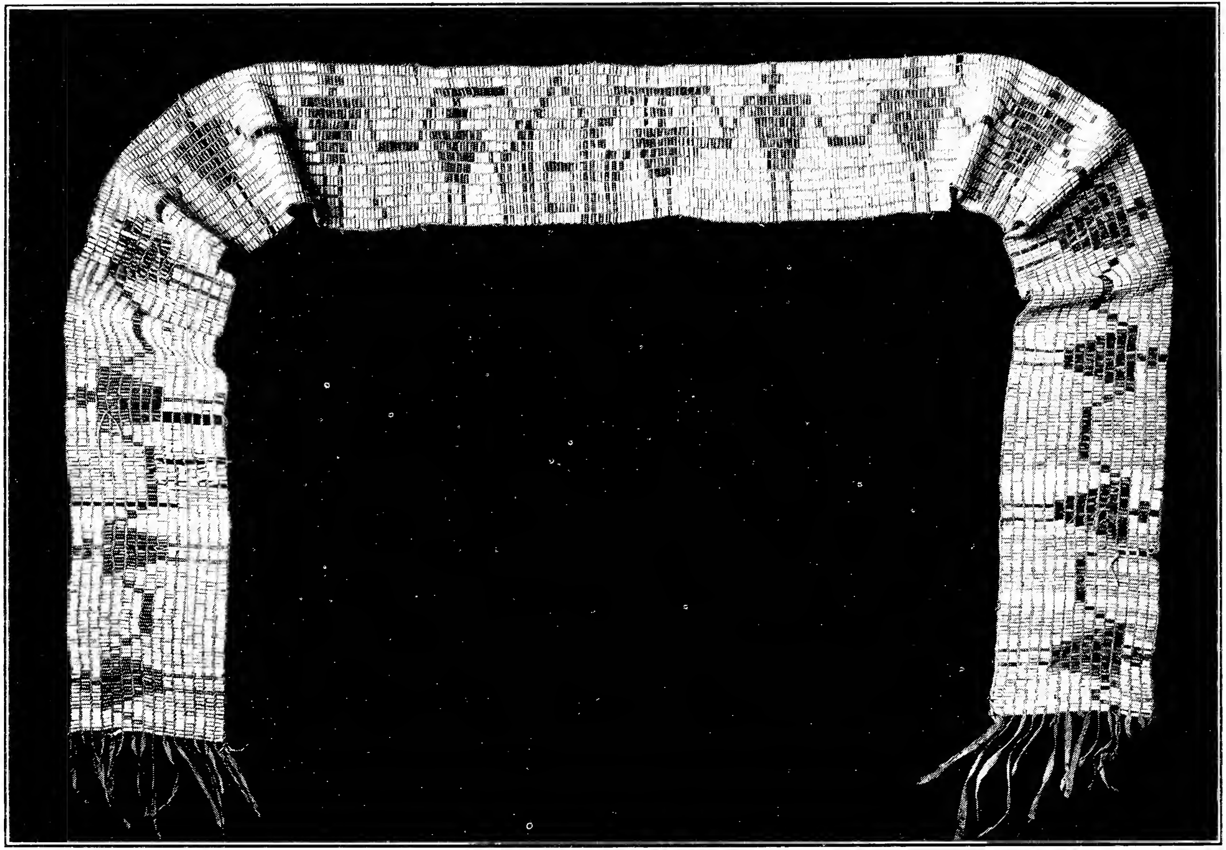

Figure 17 The Washington Covenant Belt. Used during the presidency of George Washington as a covenant of peace between the Thirteen Original Colonies and the Six Nations of the Iroquois. This is one of the finest examples of workmanship of this nature.

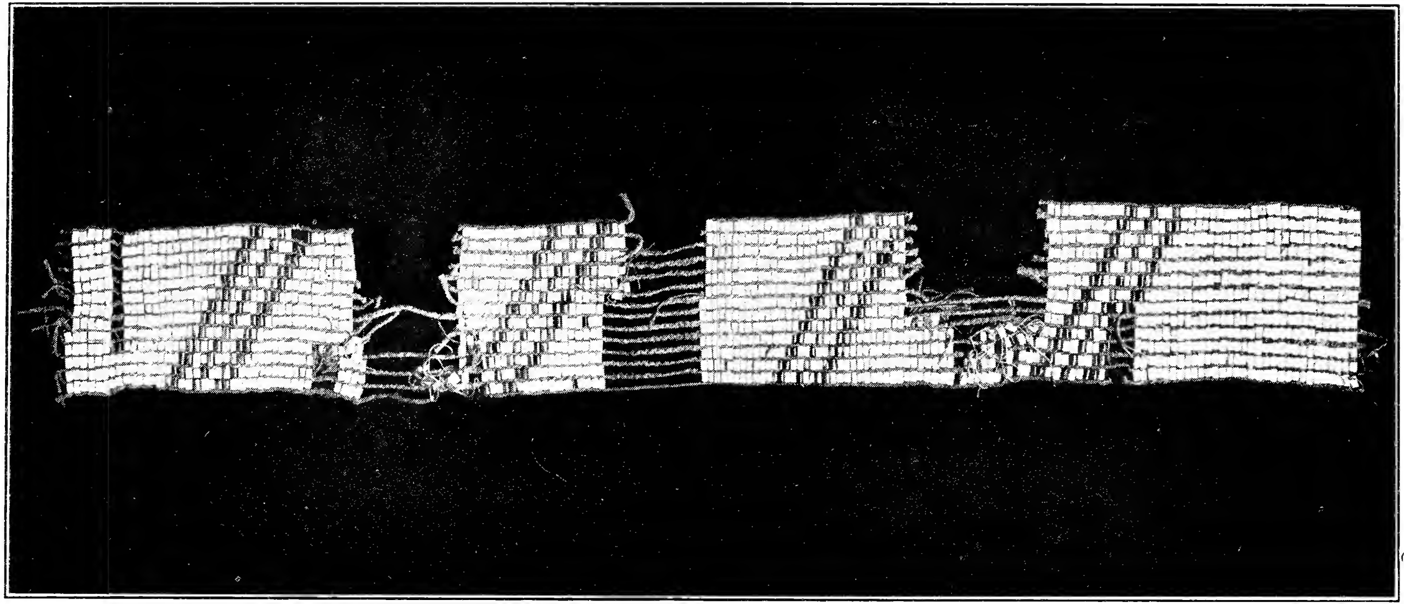

Figure 18 Belt to mark the sight of the first Pale Faces. The purple diagonal lines were used to signify agreement and were symbols of props or supports to the Long House of the Iroquois.

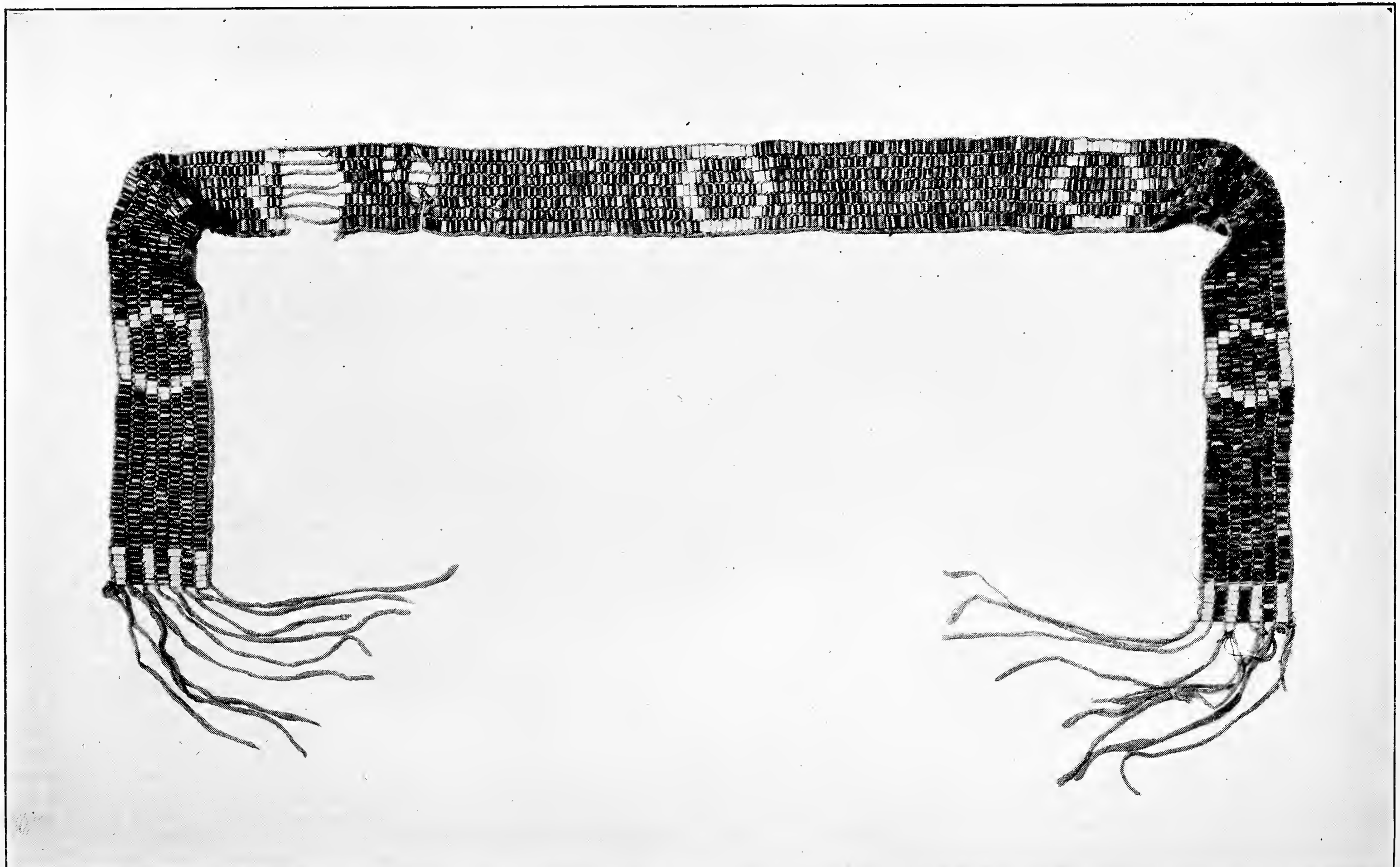

Figure 19 The Champlain Belt. The five white circles symbolized the Five Nations of the Iroquois, into whose country Champlain penetrated in 1609.

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CHARLES C. ADAMS, *Director*

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**Volume 2** treats of the land birds and begins with chapters on the ecology of birds or the relation of birds to their environment. In this volume there are 443 pages of text and 63 colored plates, besides numerous photographic text figures.

Altogether 411 species are described and their habits, ecologic relations, distribution and economic importance are discussed. The text is by Professor Elon H. Eaton of Hobart College and the colored plates by Louis Agassiz Fuertes.

The work, in two quarto, cloth-bound volumes, was published in two editions. Volume 1 of the first edition was issued in 1910 and volume 2 in 1914. This edition is out of print.

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# New York State Museum Bulletin

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No. 280 ALBANY, N. Y. February 1929

New York State Museum

CHARLES C. ADAMS, *Director*

# GLACIAL GEOLOGY AND GEOGRAPHIC CONDITIONS of the LOWER MOHAWK VALLEY

## A Survey of the Amsterdam, Fonda, Gloversville and Broadalbin Quadrangles

BY

ALBERT PERRY BRIGHAM Sc.D., L.H.D., LL.D.

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# GLACIAL GEOLOGY AND GEOGRAPHIC CONDITIONS of the LOWER MOHAWK VALLEY

## A Survey of the Amsterdam, Fonda, Gloversville and Broadalbin Quadrangles

BY

ALBERT PERRY BRIGHAM Sc.D., L.H.D., LL.D.

## INTRODUCTION

Our study covers about 900 square miles lying mainly in the lower Mohawk valley. We include a piece of the southern Adirondacks, the lowland whose northern apex is at Northville and whose southern border is the Mohawk, and the hill country leading up to the heights of the Catskill plateau.

Speaking in the language of physiography we have here a cross section of the Mohawk Province, at the northern end of that great plateau which reaches from eastern and central New York far into Alabama. The Hudson-Mohawk and Champlain depressions are the only low-level cuts across the Appalachian highlands within the United States. Hence we are here in a region of the utmost historical and economic significance.

If we consult the earliest population maps of the United States, those of 1790 and later decades, we shall find a peninsula of settlement pushing westward along the Mohawk between two areas of upland wilderness. The pioneers of Kentucky and Tennessee first subdued soil west of the mountains and they were closely followed by the frontiersmen who went up the Mohawk.

Here in succession came waves of settlement by Dutchmen, Palatines and British. Bleecker, Fonda, Amsterdam, Rotterdam, Johnstown, Perth, Cork, Galway—such are some of the memorials which these early Americans have left in our region.

Across our area runs what is, all in all, the greatest American trunk line of movement, for here were primitive trails, the batteaux of the Mohawk, and the six lines of railway track, the barge canal and one of the most thronged of American highways, while on the south border is the Cherry valley turnpike now come to rejuvenation after decades of quietude. Great industries have made well known the three cities of the region, carrying everywhere in America the names of Amsterdam, Johnstown and Gloversville.

A most distinguished name, written in the annals of New York and the Nation, is Sir William Johnson. Fort Johnson, now the home of the Montgomery County Historical Society, Guy Park, now the property of the State, and the old manor house of Johnstown, are the visible memorials of a great colonial figure and his family. Here was the home of many stern patriots who joined Herkimer to protect their beloved valley at Oriskany and to insure victory on the Saratoga battleground, and here at Johnstown was fought the last of those 98 bloody encounters which the American Revolution saw in the Colony of New York.

It is our part here to go back to times thousands of years before the white man or even the Iroquois saw the Mohawk valley, and see what the ice invasion accomplished here, and then to see in a brief survey how the mantle of drift and the related elements of the physical geography have affected the movements and works of man.

## EARLIER STUDIES

Lardner Vanuxem, in studies made about 1840, gives the occurrence of striae having a nearly east and west direction, in several places near Amsterdam, and includes a figure showing one of these gravings ('42, p. 244–45). The direction was W 8° N, quarry two and one-half miles northeast of Amsterdam, locality then known as Schelpintown. In his account of Montgomery county, Vanuxem briefly described that range of sandy hills extending across the northern part of our district by Gloversville and Broadalbin, which we shall describe as an interlobate moraine. Winds and waves seem to him to have been the forces of accumulation. He has further an interesting notice of the "Vlie," recognizing the existence of a large lake, which we now know lay in front of the Sacandaga glacier. He further made note of blue clays in the Mohawk valley, covered with sand and rolled stones.

James D. Dana ('63) early published a short paper which is of interest in the light of the fuller knowledge of today ('63, p. 243–49). The essay had its origin in information given Dana by Rev. W. B. Dwight of striae near Cherry Valley, where, near together, are glacial markings of both east-west and north-south directions. Thus Vanuxem and more explicitly Dana suggest the existence of a Mohawk glacier, although there is no sign that they discovered that its movement was up rather than down the valley. Dana then raises the interesting question of the relative age of the two sets of striae at Cherry Valley. If the north-south scratches were older, he thinks they were made by "a great continental glacier spreading southward from the remote north," of which the Mohawk glacier was a final portion that became partly outlined and independent only in the later part of the glacial epoch.

The next advance in glacial studies of this region was made by Chamberlin ('82, p. 360–365). This observer here announces the view that there was a preglacial divide at Little Falls, and that the movement in the valley up to that point and even farther on the plateau rising on the south was from east to west.

The present writer ('98, p. 183–210) presented in 1898 an outline of the physiographic development of the valley, gave further evidence that the movement was from east to west, and described the various bodies of water-laid drift which occur along the river from Rome to Schenectady.

Field studies of the four quadrangles here included were carried on by the writer at various times from 1906 to 1910. Having been long interrupted by other demands, they are here resumed and brought to a conclusion. A preliminary report setting forth main features, appears in the Fourth Report of the Director of the New York State Museum for 1907, p. 21–31. A further report of progress is found in the report of the Director for 1910, p. 18–19.

Later Professor H. L. Fairchild ('12) set forth his views of the retirement of the ice and of the glacial waters of the valley.

Other papers dealing with our region and with adjacent areas, also all references to the more distinctly geographic features, will be given in the bibliographic list at the end of this report.

## PHYSIOGRAPHY OF THE FOUR QUADRANGLES

A "quadrangle" as determined by the United States Geological Survey, in mapping the State of New York, is an area covering one-fourth of a degree of latitude and one-fourth of a degree of longitude. It is therefore about 18 miles in length from north to south and about 13 miles from east to west. Our four quadrangles are the Amsterdam, Fonda, Gloversville and Broadalbin, each named from the largest city or village within it. The four taken together from an area 36 miles from north to south and 26 miles from east to west, more than 900 square miles and not far from one-fiftieth of the surface of New York State. The altitudes are shown by contour lines which represent intervals of 20 feet. The maps, which in this report we combine into one, are known as the Amsterdam, Fonda, Gloversville and Broadalbin sheets and can be obtained from the United States Geological Survey, Washington, D. C., for 10 cents each, remittance by post office money order only.

The eastern limit of our district runs about three miles west of Schenectady. It passes through South Schenectady and, going northward, runs two miles east of Galway. On the west the border is three miles west of Yosts Station on the New York Central Railway, and four miles east of Canajoharie. The northern boundary is two miles north of Northville and runs for its whole length through the southern Adirondacks. The southern boundary is a short distance south of the Cherry valley turnpike and the villages of Duanesburg, Esperance and Sloansville.

Our area includes the major parts of Montgomery and Fulton counties, wide sections of Schenectady and Saratoga counties, and on the north a narrow southern strip of Hamilton county. On the south the Fonda quadrangle includes the northern parts of Carlisle

and Esperance, which are townships of Schoharie county. At the southeast corner of the Amsterdam quadrangle a slight, we might almost say microscopic, triangular area, belongs to Albany county. It should be remembered that the quadrangles are laid out on lines of latitude and longitude without heeding political units or boundaries.

The lowest point in our area is where the Mohawk river leaves it, at an altitude a little under 220 feet. The highest point is the summit of Pigeon mountain, just south of the Hamilton and Fulton county boundary. The altitude is slightly under 2800 feet. Pinnacle, two miles east, is a triangulation station and is given at 2514 feet.

The principal drainage of the area is by the Mohawk and its tributaries. The greater part of the Broadalbin quadrangle, however, drains by the Sacandaga river, and the southeastern section of the Amsterdam quadrangle by Norman kill. The physiography of the several parts of our area will be best understood if we first observe the Mohawk river, which follows a somewhat zigzag course, with two northward bends, at Fonda and west of Amsterdam.

The trough occupied by the river is narrow and its walls in places rise in steep slopes to levels 400 to 1000 feet above the flood-plains. This inner valley, however, does not adequately show the depth or width of the real Mohawk depression which we may regard as extending from the Adirondacks to the base of the Catskills.

The gateway through which the Mohawk enters our region is a gorge 500 feet deep, cut by the river through the uplifted mass on the west side of the Noses fault. This profound and very ancient dislocation is soon lost in the high ground to the south, but to the north its east-facing escarpment runs northward by Sammonsville, Keck Center and Clip Hill, and on to the northeast. The top of the uplifted mass in the Fonda quadrangle is a flattish plateau, topped by limestone and having an altitude of 800 to 900 feet above sea level. Yosts Station is in the gorge and Randall is just outside of it eastward. The gorge at its narrowest point barely offers passage to the river, two railways and two lines of highway. The edge of the uplifted mass is cut by several short, deep stream ways of immature form.

In both the Fonda and Amsterdam quadrangles rises the elevation within a few miles of the river southward to what we may call plateau levels. Near Glen and Currytown the higher levels are at about 1000 feet above tide, rising to 1300 and above, farther south. The triangulation station on Oak ridge is above 1440 feet, and the Cherry valley turnpike at Carlisle is at 1300 feet.

Conditions are similar on the Amsterdam quadrangle. The triangulation station Adebahr, east of Minaville, is at 1062 feet and that of Princetown hill northeast of Mariaville has an altitude of 1434 feet. Similar altitudes occur in the southern third of the quadrangle until we drop down into the valley of Norman kill. The higher parts of the quadrangles south of the river are built of horizontally bedded sandstones whose northern outcrops have been bevelled and masked with drift by the movements of the Mohawk glacier.

The chief stream entering the Mohawk is Schoharie creek, whose course from Esperance northward is wholly within the eastern border of the Fonda quadrangle. Flowing for more than 100 miles from its sources near the eastern front of the Catskill plateau, it is a broad and copious stream, which in any smaller land would be called a river. The history and significance of the lower Schoharie valley will be set forth in later sections of this report. Yatesville creek and Auriesville creek are the chief southern branches of the Mohawk in the Fonda quadrangle, while in the Amsterdam area we find the South Chuctenunda creek, Sandsea kill and Plotter kill.

The gateway by which the Mohawk passes out of our area is as notable a feature as the gorge of the Noses on the west. Within one and one-half miles of the floodplain at Rotterdam Junction the slope rises more than 1000 feet to the hilltop southeast of Waterstreet triangulation station. On the north side there is, within a single mile of the New York Central Railway, a rise of more than 700 feet. This area of hills on the north is an isolated mass, dropping northward to Glenville and extending a short distance eastward into the Schenectady quadrangle.

Our region north of the Mohawk river will be most clearly described by referring at the outset to two great lines of dislocation which have affected the land forms, the rocks, the soils and the industries of the region. Recalling the great fault line and uplift of the Noses, we may follow this line far to the northeast. Remembering that the upthrown earth block was on the west, we trace the fault past Clip hill, north of the city of Gloversville, about two miles north of Mayfield, and follow it off the Broadalbin quadrangle west of Northville. The uplift in the northern parts of the dislocation is placed at 1500 feet. It is to be understood that fault scarps are much disguised by down-wear and the accumulation of rock waste. The geologist finds signs of the actual amount of "throw," which are not obvious to the untrained observer.

The other dislocation which demands our attention is the Batchellerville fault, which runs from Batchellerville past Northampton and then bears several miles to the southeast. The steep-sided mountains east of the line are the upthrown block of crystalline rock, and here also the vertical displacement is about 1500 feet. These and other faults of this region are described by Miller ('11, p. 38–50).

The triangular area between these faults is a down-sunken block of sedimentary rocks, chiefly limestones, and shales. Consider this triangle as extending southward, widening as we go, until we base it on the Mohawk river. We have roughly an equilateral triangle of 25 miles on each side; its altitude rises from 400, 500 or 600 feet near the river to an average of about 800 feet northward over most of its surface. It is higher in the hilly belt running from the base of Clip hill eastward past Gloversville and Broadalbin, and lower in much of the Sacandaga basin. Considered from the Mohawk river we have here a reentrant lowland, flanked on either side by spurs of the southern Adirondacks.

Here, we may observe in a preliminary way, we find the leading development of human activity in our area. Here are the largest communities, from Amsterdam and Fonda, to Johnstown, Gloversville and Broadalbin, midway, and Northville at the northern apex of the sunken block. The limestones and shales afford soils superior to those of the mountains, or the sandstone plateau at the south, and the lower altitudes insure hardly mild, but at least more lenient, climatic conditions. The primary physical condition (we refrain from saying *cause*) is in the fact that the sinking of the triangular block saved the soil-forming limestones and shales from erosion and removal.

Considering then the Catskill wilderness on the south, the Adirondack forests on the north, the flanking mountain spurs and the narrow entrance and narrow exit of the Mohawk river, we may say that we have a somewhat circumscribed geographic area. What degree, if any, of historical, cultural or industrial unity, based upon physical unity, we may find here, may be better determined in the fuller studies that will follow in this report.

We should here recur to our physiographic description and give a few facts concerning the drainage north of the Mohawk river. An important branch of the river is Chuctenunda creek, which has its sources in the Amsterdam reservoir and adjoining slopes. It pursues a southwestward course for a dozen miles, past Hagaman and Rockton, and makes a rapid descent over the bed rocks, entering the Mo-

hawk at Amsterdam, flowing violently under the walls of mills which have grown up upon its banks.

The Cayudutta creek flows southwestward from Gloversville and Johnstown, makes a sharp turn at Sammonsville and enters the river at Fonda. We mention also the small Crabb kill, because it flows from Glenville through a gap in the hills, and joins the Alplaus kill in the Schenectady quadrangle.

The Sacandaga river, entering our region two miles north of Northville, makes a sharp bend at Northampton and takes a north by northeast course past Edinburg. It flows then into Stony Creek quadrangle and makes its exit to the Hudson through the gap at Conklingville. Without question this stream in preglacial times flowed southward to the Mohawk river. Its diversion will be discussed later. Through Kenneatto creek and its widespreading branches, it drains considerable territory from Hagadorns Mills, Broadalbin and Vail Mills to Mayfield and the mountains north of Jackson summit. Much of the mountain region above Gloversville drains out of the quadrangle westward.

Most of our region shows a singular dearth of lakes. This is the more remarkable in an area which was heavily scored by glaciation and is the bearer of very considerable bodies of drift. Except Featherstone lake above Mariaville and two or three small lakes in the mountains east of the Sacandaga river, we do not recall a single natural body of water save in the mountains northward from Gloversville, where are some twenty lakes, most if not all due to drift blockades in the valleys. The largest is Peck lake, which with the connected East lake and Helen Gould lake, gives a continuous water run of about four miles. The absence of lakes in the great morainic belt of Gloversville and Broadalbin is perhaps due to the porosity of the subsoils and facile subterranean drainage.

## THE ICE INVASION IN NEW YORK

We shall better understand the ice work of the Mohawk region if we take a general view of the ice movements in the State as a whole. Before we make this survey, however, we shall, for the aid of the reader who is not versed in geology, go farther afield. The center of movement for the ice sheet which swept over the northeastern states was in the moderately high grounds of the Labrador region. Thence as the snows gathered and the ice increased, there was a vast southward movement across Quebec and Ontario into the United States.

Not all the ice was formed in Labrador, for the snows of that time made ice in southern Canada and in the mountains of New

England and New York. There were local glaciers in the Adirondacks before there was an ice sheet covering almost the whole State. Imagine the St Lawrence valley filling with the moving ice, which began to bank against the Adirondacks and Green Mountains and to flow through the deep and wide Champlain valley which lies between the two mountain areas.

The ice lobe which entered the Champlain valley flowed southward. The ice that struck the Green mountain range moved to the southeast. The Adirondacks stood in the path of the oncoming ice, and split its flow, one current going up Champlain and the other up the St Lawrence valley in a southwesterly direction. Although ice is to ordinary experience rigid, it flows like a stiffly plastic mass into the lowest grounds in its path.

Ice currents flanked the Adirondacks on the east and on the northwest. On the east the stream pushed forward until it reached to the latitude of New York City. On the southwest it rounded the mountains and filled the Ontario valley, which then held no lake. In the southward movement along the Champlain channel, the ice spread out southeast upon New England and southwest upon the Adirondacks. Finding low ground west of Albany, it pushed up the great Mohawk depression and created there a westward-flowing ice lobe.

The thickening and active ice was thus surrounding the Adirondacks and rising upon their slopes and penetrating their valleys. At length it rose, as believed by most observers, above every Adirondack summit, even Mount Marcy, and swept southwestward over the whole mountain area. The glacial striae in almost every part of the Adirondacks show this direction of movement.

In this stage the ice overtopped the Mohawk flow and took a steady southwest direction across the plateau of southern New York, toward and beyond the Pennsylvania line. At the same time the ice going over the western Adirondacks and through the St Lawrence and Ontario lowlands, pushed over central and western New York in the same southwesterly flow.

This southwesterly flow dominated the State save on its eastern border, in the great Champlain-Hudson trough. Here the movement was southward. South of the lower Mohawk valley the Helderberg highland formed a wedge which split the southward Hudson flow from the Mohawk lobe and helped to send the ice at the height of glaciation southwest across the western Catskills and the upper Susquehanna region. We can picture the ice sheet as shrouding from view all of New York except part of Long Island and a corner in the southwestern part of the State.

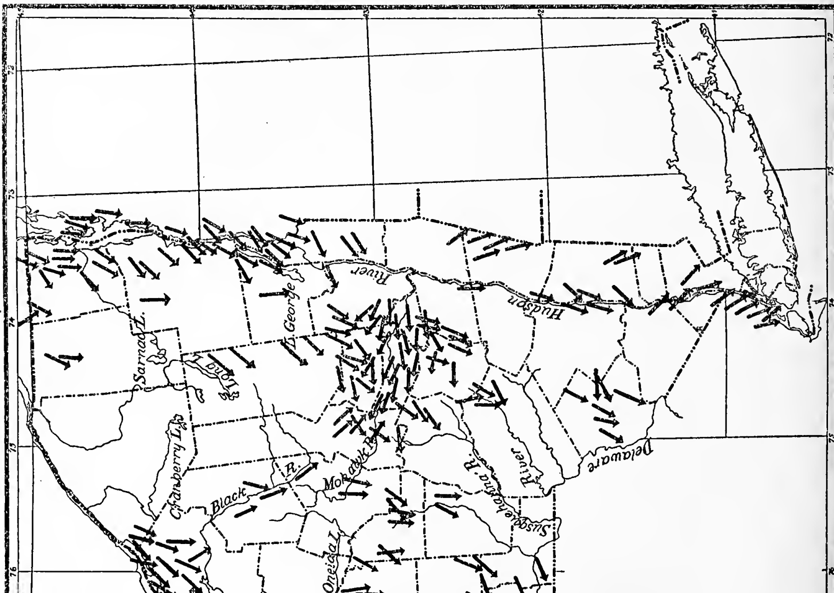


Figure 1. Glacial striae in New York.

When the great glacier melted and disappeared from New York, the events were in an order the reverse of what we have just described. When we speak of a retiring ice sheet we mean that its front on the whole melts away faster than the push from the central area sends it forward. Such melting back is not a uniform process but is accompanied by pauses and readvances. If the ice front remains in one place for a long time a moraine may be built, which in a time of waning ice cover, we call a recessional moraine. Many such accumulations of rock waste were left in the Empire State by the receding ice.

Viewing the disappearance in general, we may say that the plateau stretching from the Catskills to Lake Erie was laid bare, and perhaps small areas of the higher parts of the Adirondacks and Catskills became bare. With this lowering process, the general southwestward movement ceased and the deeper and wider valleys began to control the flow as they had done in the advance of the ice. Again the ice flowed in somewhat distinct, broad streams, or lobes, along the Champlain-Hudson trough and up the Mohawk valley to the west. Again a wide stream pushed up the St Lawrence and filled the Ontario basin.

From the Ontario basin prolonged and rather strong glaciers covered the lake counties of western New York and pushed up the valleys of the Finger lakes and the Genesee river. An offset from the St Lawrence lobe also flowed along Black river valley, around the southwestern Adirondacks and down the upper Mohawk channel as far as Little Falls. Glaciers of some strength still flowed southwestward in the southern valleys of the Adirondacks, and stagnant ice seems to have lain long and widely over the mountain region.

The Mohawk lobe had resumed its early westward flow in the valley as far as Little Falls and on the hills southward to a region south of the city of Utica. The southern plateau, extending, in general, everywhere south of the Cherry valley turnpike, was no longer covered with active ice.

Before we take up the study in detail of the Mohawk glacier in the four quadrangles, it will be useful to set forth a few general considerations.

## EXPLANATORY CONSIDERATIONS

In glacial geology the term "lobe" is used of a broad stream or body of ice advancing or retreating in an open valley or wide basin. There were, for example, glacial lobes in the valleys where now are the several Great lakes, a Michigan, an Erian, an Ontarian lobe etc. In the same manner we refer to the ice streams that entered the Champlain, Hudson and Mohawk troughs.

A lobe of glacial ice moved in what Chamberlin has called an " axiradiant " fashion, that is, along with a central forward or axial flow there were divergent flows curving outward in a radial manner toward the rim of the basin on either side.

When we say that a glacier moved up a valley, we do not mean that it controverts the ordinary law of flowage. Water is pushed up inclines out of depressions in the bed of descending streams. The surface of the streams inclines in the direction of flow, while the bottom currents may move uphill. This is not a perfect analogy but in some measure helps us to see how a great glacier might be pushed up the valley of the St Lawrence, or the valley of Seneca lake, or the valleys of the Champlain and the Mohawk. Champlain ice was pushed up to the locality of Whitehall and Fort Ann by the impulse of vast and thick ice fields in the St Lawrence Basin. The surface of the lobe was all the time inclined southward.

Mohawk ice was pushed westward to the longitude of Utica and upward from the Albany region to altitudes of 1600 feet. The impulse was the push of the Champlain-Hudson mass, backed by the mountains of New England, which thrust the ice uphill along the Mohawk. The surface of the ice at all times declined westward.

We observe further, that in our region, as in most glacial tracts outside of high mountain areas, the major or more massive features of the topography are of preglacial origin. In other words, the mountains, plateaus, escarpments and main valleys all came into existence before the ice invasion. There is not a foot of surface in our four quadrangles which is the same as before the glacial period. But the Adirondack elevations of the Gloversville and Broadalbin areas were made inconceivably long before the glacial time. We may say the same, though the degrees of geological antiquity are widely variant, of the Mohawk valley in the broad sense, of the Noses escarpment and of the high areas south of the river.

In brief, the changes wrought by ice were universal and important, and modified, but did not destroy, the preexisting great features of the region. Long experience in teaching the facts of glaciation makes it seem necessary to the author to caution the reader against the conclusion that ice was revolutionary in its effects. What the real and everywhere striking results were, will appear as we proceed with our study of the land forms and surface deposits of our region.

Some explanation of glacial striae, or rock gravings, is desirable at this point. Glaciers gather or *pluck* rock masses, large and small, in their course, and the bottom ice is often shod with these fragments. As they are shoved over the bed rock surfaces by the moving

mass, they produce the gravings to which we refer. These vary from the finest hair lines to pronounced grooves and mouldings. They are preserved or not, according to the character of the bed rock and its situation. They are least apt to be found on soft shales. They are finely preserved on limestone unless that rather soluble rock has been long at the surface and exposed to weathering.

Sandstones being hard and relatively insoluble take and preserve the graving records well, especially if of rather fine grain. The crystalline rocks are variable in this respect and may show flutings where they do not preserve fine lines. Striae are often found in the best state of preservation where the overlying drift has protected them until excavations for road-making or quarrying have brought to light the surface of the rock.

It is to be understood that the striae found in the observations of the geologist are, like fossils, only an infinitesimal fraction of those which exist. Could we strip the drift and all fragmental material from the bed rocks of New York we should find tens of thousands of square miles of rock floor scored by these tools of the ice sheet.

A further fact about these memorials of the ice invasion, it is now particularly important to understand. Much of the surface of New York was covered by the moving ice of one or more ice invasions for tens of thousands of years. During all such durations glacial striae were being made and destroyed. How many different sets of striae thus came into existence and were filed away by the ever-working ice, we can not even imagine.

What we do know is that the striae now found in a region represent the very last ice movements of that region. Not all the existing striae are of equal age, because the ice wrought later on some grounds than on others. Thus we have already given ground for the inference that striae in the heights of the Adirondacks and the Appalachians are older than those of the Mohawk or St Lawrence Valleys, because these lower grounds longer retained active currents of ice.

## RECORD OF STRIAE

Somewhat more than 80 examples are recorded in this list and plotted on the map. On account of the heavy cover of drift and water-laid material, the smallest number appears on the Broadalbin quadrangle. Most of the localities are sufficiently described as to position to enable the interested observer to find them. All the readings given are magnetic.

### Broadalbin Quadrangle

One mile north of Northville by roadside on crystalline rock, S 10° E.

One-half mile east of Northville on Potsdam sandstone. Ranges S 10° E to S 10° W, given on map as S.

Two miles south of Sacandaga Park on Potsdam sandstone, S. 35° W.

Two and one-half miles south of Sacandaga Park on Little Falls dolomite, S 24° W.

Two miles southwest of Cranberry creek, in limestone, Mercer's quarry, S 45° W.

Near Fox hill above Batchellerville, two localities on crystallines, S 28° W and S 35° W.

Three-fourths mile south of Mosherville on sandstone, N 30° W.

Near North Galway, northwest, on quartz, two localities N 38° W and N 45° W.

Three-fourths mile east of Amsterdam reservoir on sandstone, N. 70° W.

One mile west of Galway N 60° W. One-fourth mile farther west N 57° W.

### Amsterdam Quadrangle

Eastern part of Amsterdam by Kellogg railroad, and eastward N 65° W, N 70° W, N 72° W.

Two and one-half miles southwest of Galway, S 80° to 85° W.

One-mile north of Glenville on sandstone, direction due west.

One mile southeast of Manny's Corners, by road to Cranesville, on sandstone, N 80° W.

Two miles north of Hoffman Ferry on county line road, by roadside, N 80° W.

North of Rectors Station, two miles from Mohawk river, on eastern boundary of Amsterdam quadrangle, S 70° W.

One-half mile west of Pattersonville, N 74° W.

One-fourth mile west of last, N 50° W.

One-half mile north of Rynex Corners, on sandstone, W to W 10° S.

One-half mile north of Princetown, two localities, S 60° W and S 75° W.

One-fourth mile east of Mariaville pond, on sandstone. N 80° W.

South of Princetown Hill, on planed area of sandstone, direction due west.

Two miles east northeast of Duanesburg on upper road near road intersection, S 70° W to W.

One and one-fourth miles south of Scotch Bush, on sandstone, by road junction, S 45° W.

One and one-half miles west of Scotch Bush, S 45° to 60° W.

One-half mile southeast of last, S 45° to 55° W.

Three-fourths mile northeast of Millers Corners, S 20° to 30° W.

Two and one-half miles south-southeast of Braman's Corners, by schoolhouse, S 80° W.

Three-fourths mile south of last, slightly variant, average west. Same directions slightly south, also one-half mile west.

### Fonda Quadrangle

One-half mile north of Tribes Hill on limestone, N 70° W.

West of Noses Escarpment on the high ground west of Sammonsville and Berryville are three sets of striae, with directions N 60° to 65° W, N 60° to 70° W, and N 64° W.

Southwest of Randall above road intersection, S. 72° W.

Three miles west-southwest of Mill Point, two miles northeast of Charleston, four localities (see map) directions respectively taking the exposures from north to south, S 80° W, S 76° W, S 76° W, and due west.

One mile southeast of Charleston, S 68° W.

Three miles east of Charleston, S 65° W.

Two miles northwest of Charleston, near road intersections, four sets of striae, all S 70° W.

Two miles north of Rural Grove, S 67° to 78° W.

One mile east of last, S 70° W.

One-half mile west of Carlisle, N 80° W.

One and a fourth miles west of Sloansville, N 60° W to W.

One mile north of Oak ridge, Wand's quarry, W.

Three-fourths mile southeast of Carytown, N 85° W.

Two sets on road between Oak Ridge and Esperance, N 76° W.

One-half mile southwest of Burtonsville, S 70° W.

One mile north of Burtonsville, S 65° W.

Close to above by schoolhouse, directions, S 45° W, S 65° W, and W.

### Gloversville Quadrangle

Two miles north-northeast of Mayfield, Merl Haines quarry in limestone, groovings, S 30° to 40° W.

One-third mile west of altitude figure, Clip hill, on crystalline rock, N 66° W.

Near west end of Mountain lake, moulding rather than scratches, fairly trustworthy, S 20° W.

One-half mile south of Bleecker, by roadside, S 45° W.

In the edge of Bleecker, south of bridge, on roadside, S 40° W.

One mile from Bleecker, on road to Bleecker Center, S 40° W.

One-half mile toward Bleecker Center from last-named locality, on roadside, S 50° W.

One-half mile north of East lake, S 45° W.

One mile east of Bleecker Center, on roadside, faint but trustworthy, S 30° W.

Opposite (east of) Lily lake, on roadside, S 40° W.

One-half mile north of Bleecker, S 40° W.

One mile west of Bleecker Center, top of hill, in front of Roman Catholic Church, S 45° W. Outcrop extends 40 rods down road to east, showing striae of same direction.

One and one-half miles east of Pine Lake Post Office, on rock sloping 30° to south, S 80° W.

Two miles east of West Caroga lake, on Bleecker-Caroga town line, ledge on west side of road, S 75° W.

One-half mile south of last, in field of roches moutonnées character, partially drift covered, S 60° to 70° W.

West of lower end of Peck lake, on road leading northeast from main road, S 45° W.

On main road midway between Peck lake and East Caroga lake, on irregular ledge sloping steeply to west, S 35° to 55° W.

North end of Wheelerville, N 80° W, with some grooving varying to S 80° W.

Near Indian lake, furrow S 80° W, may be regarded as fairly trustworthy.

One-half mile west of Lindsley's Corners, groove running north by south. Same place, probable scratches, S 20° W.

One half mile south of Lindsley's Corners, on roadside, good example, S 50° W.

West of Pinnacle Post Office, S 50° W.

Summit of Pinnacle, 2514 feet, considerable areas of roches moutonnées around the United States Geological Survey Station. Fine lines have weathered out, but in several places broadly concave furrows run S 40° to 50° W. These furrows begin abruptly on the stoss side and are less apparent on the lee side. One or two sharp and narrow gougings are probably trustworthy.

Reference may be made to striae found slightly west over the border of Lassellsville quadrangle. North of Arietta, at the northeast corner of the quadrangle, are striae running S 70° W. On the road from Bradtville (Lassellsville quadrangle) 100 feet above road on steep slope facing east, N 65° to 70° W. This locality is just west, on the map, of the name Caroga, denoting the creek. These striae fall in line with those of Clip Hill four miles east-southeast.

It will be noted that they are at a right angle with the striae of the mountains northeastward. Three miles east of the village of Lassellsville on the south side of the main highway are roches moutonnées having a direction of N 50° W.

## DISCUSSION OF THE GLACIAL STRIAE

In order to bring out more clearly the meaning of the glacial gravings in our region, figure 2 has been prepared. The four

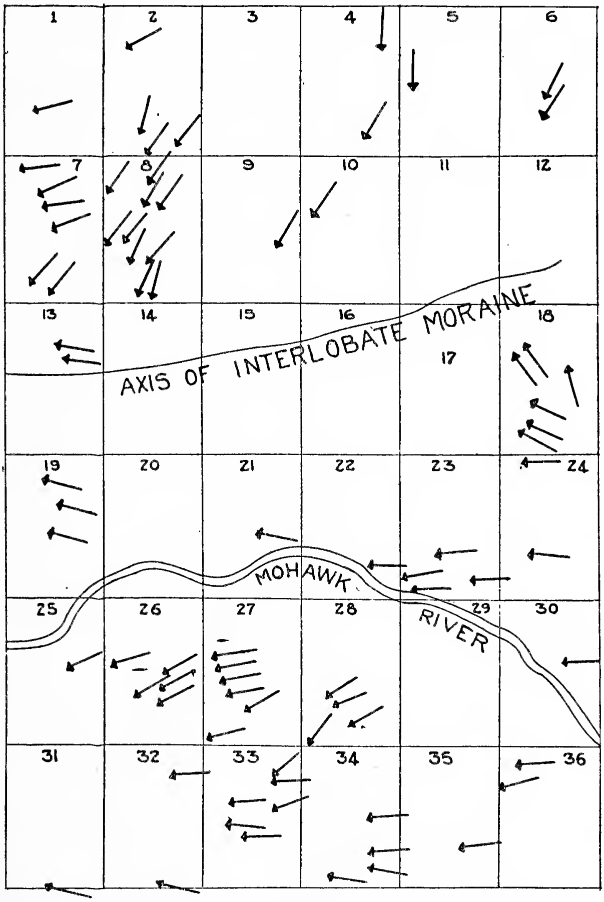


Figure 2 Glacial scratches in the four quadrangles.

quadrangles are divided into 36 sections each representing one-twelfth of a degree of latitude and longitude, as indicated on all sheets of a scale of one mile to the inch. The striations have been plotted, the only other data being the course of the Mohawk river and the axial or median line of the interlobate moraine which crosses

the Gloversville and Broadalbin quadrangles. The sections of the map are numbered for easy reference.

It is at once apparent that most of the striae north of the moraine have a general southwesterly course, varying from south-southwest to west-southwest. These directions are in harmony with Adirondack glaciation as we know it in many quadrangles to the northward. The north by south gravings in sections 4 and 5 are in the Sacandaga valley near Northville and are evidence of the control of that valley, exercised upon late ice flows, and probably also on the lower ice of the thickest or maximum flow.

The remaining exceptions are two records in section 13, which are a little north of the axis of the interlobate moraine. They are, however, within the northern half of the moraine belt and therefore within the sweep of the Mohawk lobe as it moved westward.

The greater part of section 10 is covered by the Sacandaga marshes, as 11 and 12 to the east are deeply buried in glacial drift. With the exception of section 13, referred to above, no section crossed by the morainic axis has yielded us a graving record.

Within the domain of the Mohawk lobe the trend of striae is prevailingly westward, but with interesting variations mostly of plain meaning. We see at a glance the "axi-radiant" flow of the ice mass. Along the axial parts of the flow at its eastern entrance upon the wider Mohawk depression, the directions are westward. There are two localities of striae north of the river, tending to the northwest. The first is on sections 13 and 19, all of these striae being on the plateau above the escarpment of the Noses fault.

The other area is in section 18, Broadalbin quadrangle, the district near Galway, North Galway and Mosherville. Here the average direction is about northwest. The northward tendency is more than one would expect to find, within so short a distance of the locality in which the Mohawk lobe began to push away from the Hudson Valley ice. Possibly there were local reasons for northward divergence, but none was discovered.

The reader will observe the wide sweep of the central area in which few records appear. From the north border of sections 26, 27 and 28, to sections 11 and 12, the only examples found are in sections 21 and 22. In other words, we range with but one exception in a broad belt from the village of Glen past Fonda, Johnstown and Gloversville to the Sacandaga river and the eastern border of the Broadalbin quadrangle, over a region that has revealed no record.

When we come to the plotted records south of the Mohawk river, the "axi-radiant" movement is very clearly shown, in a consistent

west by southwest trend. This is well seen from Scotch Bush past Glen and Charleston, going westward. The same tendency is evident but less strong in the southern sections of the Amsterdam and Fonda quadrangles. On the south border, as beyond Sloansville and Carlisle, are scratches which point a little north of west. Here the valley troughs of Norman kill and Cobleskill seem to have had some influence on the glacial movements.

Following what has been said, we may be subject to erroneous inferences as to the part played by the immediate valley of the Mohawk. To avoid this let us now observe that the river pursues a sinuous, not to say angular, course across our two southern quadrangles. From Amsterdam toward Schenectady it is in a narrow steep-walled valley having nearly a southeast direction. Except through the gorgelike gateway at and below Rotterdam Junction, access to or from the Hudson lowlands is barred by broad masses of hills reaching 800 to 1000 feet above the river.

A glacial flow from the northeast or even from the east, would be against these hills and athwart many miles of the river before the stream issues upon the Schenectady lowland. Hence we may without hesitation say that the inner trough of the Mohawk is too narrow and too crooked to have controlled the flow of the Mohawk glacial lobe. We must look to the Adirondacks farther north and to the Helderberg escarpment and the Catskills farther south for the real gate posts between which the invading ice flowed into and was pushed along the Mohawk belt to central New York.

## STRIAE BEYOND THE BORDERS OF OUR AREA

Referring to certain gravings in sections 1 and 7 of the skeleton map, we note a direction nearly or quite due west. Similar records occur just over the border, in the northeast corner of the Lassellsville quadrangle, these striae being just north of the Hamilton county boundary. It would seem that the westward thrust of the Mohawk ice in time of greatest vigor may have pushed the Adirondack flow into partial conformity to its westward direction.

Also in Lassellsville quadrangle westward from section 13, opposite its northwest corner, near Bradtville, are striae on a steep east-facing slope, with a direction of N 65° to 70° W. These are in line with the two records shown on section 13 and they show the strong flow of Mohawk ice which reached an altitude of 1200 feet above the Noses escarpment, and then passed on the altitudes of 1600 to 1800 feet west of Caroga creek. In harmony with the striae just named are the roches moutonnées east of Lassellsville.

On the east of our locality in section 30, in the hill region west of Town House Corners, Schenectady quadrangle, Professor Stoller has noted two examples of striae running south of west. The more northerly of these runs S 57° W and is midway between our record on section 30 and Van Etten triangulation station, just over the border of the Schenectady quadrangle. In the Saratoga quadrangle between East Galway and Rock City Falls we have a record of S 52° W.

A discussion of the crossed and other scratches of the Berne quadrangle and westward will be given in the section which describes the limits of the Mohawk lobe.

## THE INTERLOBATE MORAINE

We begin our description of this belt of morainic hills by observing that the half of the city of Gloversville lying east of Main street is built upon some of these elevations which here and throughout most of their course are of a highly sandy character. East of the city on the Broadalbin road, the hills are of low altitude, but the ground is typical in its irregular form and sandy almost to barrenness, although there are many homes and there is some cultivation.

From two to four miles out of Gloversville several drumlins rise out of the sand hills, contrasting with the morainic hills, somewhat as an oasis differs from the surrounding desert. The morainic belt narrows north of Vail Mills and passes on the north of Broadalbin with a width of less than a half mile. Just to the westward of Vail Mills, however, the moraine is about four miles wide and is crossed diagonally for more than that distance by the railway between Vail Mills and Broadalbin Junction. It then continues southward of the railway into Gloversville.

We may profitably trace the moraine eastward on its southern border, leaving Gloversville on the road leading to West Perth. It is not easy to draw a boundary line between the morainic sand and the till to the southward. This section shades from moraine into drumlin forms and from sand into till. The first impression that the Mohawk lobe partially overrode the moraine, masking it with its own forms and material, was confirmed a year later, when on a second visit, the moraine showed a drumloid south edge with more vegetation, more tillage, fewer pines and more deciduous trees than it exhibited when seen from the north.

Following the moraine westward from Gloversville we observe that the city west of Main street is built mainly on hills of till. West

of the city we find the moraine, which widens past Meco and thence westward, is more than three miles wide to the base of the Noses escarpment and is a confused mass of sandy hills with thoroughly obstructed drainage. Under the escarpment west of Meco the sand hills show many boulders and they are all constructional morainic forms not modified by wind action.

The moraine continues with strong forms and massive breadth to the western border of the quadrangle. The hills are high and many of them sandy in the desert sense, with few boulders. Many sections show discordant stratification. A mile west of Cork the map shows several depression contours. There are no ponds, their absence being due to the light and porous character of the materials of the moraine.

Eastward of Broadalbin the moraine is less coherent, being found in long tongues and patches. These bodies of washed drift conform to the general northeast by southwest trend of the topography and are not so obviously of an interlobate character. They are on the north edge of the belt of territory in which the Mohawk lobe began to swing westward and diverge from the Hudson lobe. This movement was therefore in a direction nearly parallel to the ice movement from the mountain mass in the northeast parts of the Broadalbin quadrangle.

A narrow morainic strip of washed drift extends from Broadalbin past Union Mills. Another belt stretches northeast from Hagadorns Mills. Other areas are found about Barkersville, especially to the east. West of Barkersville are bouldery morainic hills of till. Southward from these localities the topographic forms show no prevailing trends. This is significant in view of the fact that our examples of striae pointing northwestward lie in this region, near North Galway, Galway and Mosherville. While as already stated, the pronounced north element in the direction is not easy to explain, we have in the patchy moraines, the irregular trends of the hills and the direction of the gravings, evidence of an area of doubtful and shifting movements of ice masses that were coming into opposing conditions in relation to each other. Farther west the southward course of the Sacandaga ice and the westward course of the Mohawk ice have left clear records in the moraine, in the striae and in the linear elements of the topography.

An interesting succession of waterlaid drift hills in the Saratoga quadrangle, as described by Professor Stoller, seems to correlate with the washed drift last described in the Broadalbin quadrangle. These hills stretch from Corinth to East Galway, the only important break being around Porter's Corners. They lie on the lower slopes of the high ground which extends from the Saratoga region to the

eastern limb of the Sacandaga river in the Broadalbin quadrangle. They are described as kame terraces. (Stoller '16, p. 20–22).

Professor Stoller, however, notes very carefully, elements of topography and structure such as the preserved kames, which show that these masses are not always flat-topped with ice-contact slopes. It does not therefore seem in conflict with his interpretation to suppose that considerable parts of this belt of hills are morainic and were laid down against the mountain side when the Hudson lobe was still active and exercising its thrust into the Mohawk opening.

We should thus have with little interruption a series of washed drift masses, from Corinth to the plateau of the Noses fault, a morainic belt lateral to the Hudson lobe in the east, becoming interlobate, as already described, in the west.

West of our area a narrow belt of kames has been observed on both sides of the main highway from two or three miles east of Lassellsville. This is in alignment with our interlobate moraine passing by Cork, down the Noses escarpment to the east.

Cushing refers to a morainic belt crossing the Little Falls quadrangle from the northwest by way of Barto hill and Salisbury Center, to the eastern edge of the quadrangle (Cushing, '05, p. 75). Whether this moraine is continuous with the Lassellsville moraine and that of Gloversville has not been determined.

## PERTH-BROADALBIN TILL PLAIN

In the northern part of the township of Perth and the southern section of Broadalbin is a high plain showing an evenness of surface unmatched by any equal area in the region here studied. It reaches from Perth village eastward toward West Galway, and extends northward several miles, its boundaries as shown on the map being somewhat arbitrary. The altitudes range from 800 to 950 feet, streams have made little headway in dissecting the area, and the central parts show no surface drainage that could be mapped.

There is no considerable deposit of sand save at one locality. Wells nowhere reach the bed rock. Such evidence as we have indicates that we have here, south of the morainic belt, a till plain of remarkable smoothness, with deposits of considerable depth.

The locality mentioned as exceptional is a narrow east by west ridge, lying toward the east, and north of the center of the plain and colored as kame. It is moderately morainic, with low knolls of sandy loam and some small kettle holes. Toward the eastern end is an opening of sand, with large stones and apparent absence of stratification.

We have here, closely related to the interlobate moraine, a massive deposit of doubtful origin. It may have been an overridden and smoothed drift of earlier deposition and the powerful Mohawk glacier may have thus pushed vigorously over its northern field as it seems to have done southeast of Gloversville and west of Johnstown. In any case the ridge of moraine just described has not been overridden and may have been built between the northern and southern icefields. The suggestion just made, regarding a push of the Mohawk glacier deserves a further word.

We consider first the fact that the Mohawk lobe must have strengthened in its westward flow or regained it from a state of comparative inaction, after the southwestern flow in the Adirondacks ceased to be effective. Stagnation or an earlier ablation in the Sacandaga region would have facilitated a northward, smoothing drive across the previous interlobate mass about Perth, and might have made those northwest striae which we find in Galway, and to the westward would have moulded the south edge of the moraine toward Johnstown and Gloversville into drumlin forms.

## THE SACANDAGA GLACIER

When the northern ice was in its maximum flow down the southern Adirondacks there was, strictly speaking, no Sacandaga glacier. As the ice thinned, however, flow in this region concentrated upon the Sacandaga valley, which, widening into the great triangular lowland south of Northville, gave the ice opportunity to fan out into what we may without serious impropriety call a glacial lobe.

We have considerable evidence as to its frontal positions in various stages of its recession, when it was, by melting, uncovering the areas of the great "Vly" and pouring its waters into the Lake Sacandaga, later to be described.

A belt of low, morainic hills breaks off from the interlobate moraine southwest of Munsonville and extends without much interruption to the bend of the Sacandaga river at Northampton. Here are low and flowing contours, free from stone. The belt is between sections of the great marsh, is thickly settled by prosperous farmers, working a soil of sandy loam and extending their culture very much into the lands given as marsh by the topographer. This belt is quite probably a moraine laid down in the waters of the developing Lake Sacandaga, and in any case its gentle contours and silty soils show that it was mantled with lacustrine deposits. We do not know how much of the bases of these areas at Munsonville may have been buried by lake and marsh deposits. In any case they seem to represent a pause in the recession of the ice in the Sacandaga valley.

On the west side of the lowland and west of Tamarack swamp we observe a belt of till moraine which may be contemporaneous with the knolls and outwash of the Munsonville belt. Northeast and north of Osborn Bridge two narrow belts of kamelike drift rise on the slopes. Near their upper ends is a patch of till moraine. These bodies of drift are terminal to later stages of the recession and fall in well with the morainic areas west of Sacandaga Park.

These masses of washed drift seem to correspond well to a terminal moraine found at the south or upper end of Gifford valley, a short mountain valley whose north-flowing stream enters the Sacandaga on the west above Northville. The moraine is on the col between this deep, short valley and the great lowland south of Sacandaga Park. We have here a remarkably complete small example of what a glacier and its waters will produce. The moraine is of fine crescentic shape, of sand and gravel, forming a ridge, highest at the east end, one-third of a mile long, with a spillway at the west end. Here the moraine is low and narrow and south of it is a short gorge. West of the gorge the rock is swept bare and shows roches moutonées forms. South of the moraine, slopes of sandy outwash sweep down into the north end of Tamarack swamp. The mountain west of Sacandaga Park separated this small glacier from the parent trunk glacier which then lay over the site of Northville.

Before leaving this section of the Sacandaga basin the reader will find it worth while to observe, on the general map, the succession of deposits as we pass up the hillside adjoining the more northerly of two masses of washed drift. Read the following series from the bottom upward.

8 Ground moraine (till)
7 Kames
6 Sand plain
5 Ground moraine (till)
4 Northville, or Sacandaga delta
3 River terrace
2 Flood plain
1 Sacandaga river

Proceeding across the ridge east of Northville we find interesting conditions about Edinburg. West of Edinburg we have a sand plain, bisected by the waters of Butler creek. It is a delta built against an ice tongue which occupied the main valley at the time of retreat. North of Edinburg on the west side of the river are strong kames which, directly north of the village, rise 260 feet above the river.

The kame belt is mainly west of the valley road, but the sands run across the road and meet the flood plain of the Sacandaga. In the southern or higher part of the kames near Edinburg the sands are quite barren and considerable patches are exposed. The surfaces are almost free from boulders though one 6 by 8 feet was seen by the roadside. The kames decline at the northern border of the quadrangle by Coldbrook Cemetery and a schoolhouse. On the adjoining, or Stony Creek, quadrangle, lateral or kame terraces appear to extend some distance down the river with heights of 150 to 200 feet. The hook-shaped extension of the drift mass toward the river, east of Edinburg, as one goes toward the bridge, suggests the presence of a terminal moraine breached by the stream. We note the bouldery till on the lower slopes east of the river and north of Batchellerville.

Thus the various conditions about Edinburg show a noteworthy pause in the ice recession here, corresponding well with terminal deposits north of Osborn Bridge and west of Sacandaga Park. The ice front would be likely to stand a little farther south in the more open valley, fed by the ice of the upper Sacandaga basin. North of Northville, near the north border of the quadrangle, is a massive moraine on both sides of the river but strongest on the east, standing at the head of the delta of the glacial Lake Sacandaga.

Before leaving the Sacandaga glacier we may profitably refer to a belt of terminal moraine which Professor Stoller has described as found south of Corinth and Palmer, in the Saratoga quadrangle. His account is on pages 22 to 25 of the bulletin to which reference has already been made. This moraine correlates well with the recessional deposits found in the northern parts of the Broadalbin quadrangle.

## DRUMLINS

More than forty of these ellipsoid hills in our region are so nearly typical in form that they have received recognition on the map. This is a small number as compared with the great development of these forms in western New York, Wisconsin and parts of New England, but we have enough examples to show that in the southern half of the Gloversville quadrangle and in the northern half of the Fonda quadrangle there existed in the later stages of Mohawk glaciation that condition of balance between the erosive and depositional capacity of an ice sheet which permits the building of drumlins.

Many other hills might, without violence, have been mapped as drumlins but it seems better to include them under the general category of drumloid and linear forms, which will be taken up in

the next section of this report. The drumlins are developed in the greatest number and perfection about the cities of Gloversville and Johnstown.

Some of these hills in their most characteristic form may be seen by driving four miles from Gloversville on the road to Vail Mills, turning northward to Mayfield and returning to the city by the road which is directly north of the Fonda, Johnstown and Gloversville Railway. They are short, broadly ellipsoid forms in their ground plan and rise to heights which give them steep slopes. Several are a half mile each in length and have heights of about 100 feet. In the northeastern section of Gloversville, near the race track, is a drumlin about 60 feet high (fig. 21) while at the northeast of it is an example having a height of about 150 feet. North of this, across the railway, we have a hill which exhibits what we may call twin drumlins. Some of the drumlins are bouldery in places or have morainic ground around them or on their lower slopes.

In the western part of Gloversville and northward along the road to Mountain lake are several drumlins of more or less perfect form. The hill north of Kingsboro on the west of the road leading to the mountains has a rather imperfect or irregular crest line, is bouldery on its east slopes and suggests that the ice ceased to be active before the drumlin could receive a symmetrical modeling.

Going north toward Mountain lake, we find a group of five drumlins one-half mile north of the east by west section of the electric railway. One of these hills carries the highway. The contours do not show the rather spacious valley between the drumlins and the mountain side on the north of them. All these drumlins are quite abundant in boulders as we might expect from their proximity to the mountain slope along which the glacier proceeded from the northeast. These hills and those on the road to Mayfield show how the Sacandaga ice tended to swing into a direction parallel to the lines of movement of the Mohawk ice. It is significant that several drumlins north and east of Gloversville and around Johnstown have fields of boulders on their eastern or stoss slopes. In the drumlin group toward Mountain lake, the east end of the drumlins and of the troughs between them is in places so thickly set with boulders that one might almost step from one to the other across the fields. At one point the bouldery and fluted side slope of the drumlin is banked with sandy moraine for some distance up from its base.

From the top of the most easterly of this group of five drumlins one has a remarkable view of the varied crest lines of glacial forms. The ellipsoid profiles of the drumlins are visible north, south, east

and west. Southward is seen the irregular and notched profile of the morainic belt running west from Gloversville.

Most of the hills in and around Johnstown are drumlins, and some are well and symmetrically shaped, all showing distinctly the westward movement of the molding agent. The leading topographic feature of Johnstown is the great circular drumlin south of the principal east and west thoroughfare, the hill itself carrying more than a dozen streets on its slopes and summit. This topography continues all the way to West Perth, six miles to the east. The Roman Catholic cemetery of Johnstown east of the city is on the west end of a large drumlin. The road to Tribes Hill crosses the southwest slope and here sections of till are sandy, have few boulders and show fragments of Utica shale eroded from the bed rock of the region.

Four drumlins lie nearly in a north and south series south of the cemetery, east of the railway. All have moderate size, in area and in height, and all are steep at the east end. Other drumlins in this neighborhood are close to the railway on the west. Drumlins lie west of the city, encircling the Battle Monument and between the roads that lead to Cork and to Keck Center.

As we have before suggested, the drumlins so mapped do not adequately express the drumlin-making activity of the glacier around Gloversville and Johnstown. The field notes describe a view from a slope south of the interlobate moraine and facing it. "It (the moraine) is distinguished as far as visible as a belt of light forest in contrast with the general clearing of the ground southward. The great ridge breaks into a sea of drumlins at its west end, and the hills are more individual and typical forms as we go farther west toward Johnstown."

As throwing light on the latter part of this section we should refer to molded drift of this character at the base of the Noses escarpment. As one leaves the Fonda delta at Perryville and proceeds westward, great drumloid spurs of till project from the escarpment and reach down to the delta. Many boulders are on them and at the east end they are typical drumlins in their form.

A few drumlins were mapped south of the Mohawk river in Glen township. Combining the Gloversville and Fonda areas, we see that the typical drumlins are in a belt extending from Mayfield past Gloversville and Johnstown to a few miles south of the Mohawk river. Westward of this belt is the long, bold, east-facing escarpment of the Noses fault. This is a topographical feature of such strength as materially to have retarded the westward flow of the Mohawk

ice, especially as it thinned and became weaker in its action. It seems clear then that here we have the conditions of moderate thickness and flow which give an ice sheet its capacity to model the drumlin forms by an overriding which packs and shapes the drift, but does not move it effectively to more advanced positions in its course.

## DRUMLOID AND LINEAR TOPOGRAPHY

We include here forms of variant shape and structure which are enough like drumlins in origin and materials to deserve the descriptive adjective drumloidal, or if referring to a single hill, drumloid, used as a substantive. In shape these hills may be short and show the drumlin form at one end only. As examples note the trailing out from massive drift, of drumloid extensions westward, three miles northeast of Cranesville on the road to Blue Corners. Similar east-by-west drumloidal forms characterize the slope east of Fort Johnson and north of the river toward Amsterdam. The same trailing out of these hills to the westward is seen east of Stone ridge south of the Mohawk river. The forms west of Perryville banked against the Noses escarpment are partial drumlins also, but here we have the stoss rather than the lee ends of the hills.

It is clear from the description of the drumlin areas in the foregoing section that hills approaching the drumlin form are found in close association with the interlobate moraine hills which did not merit distinct mapping as drumlins. This is true of the great aggregate of ellipsoïd elevations about Barkersville and Mosherville, where the drift is thick, is shaped by overriding ice moving to the southwest, and where the proportion of drift cover to rock base in the hills is in most cases very doubtful. We can be sure there is much more drift and therefore a nearer approach to the true drumlin than is found in central New York. There, in the zone where the Mohawk and Ontario waters separate from those of the Susquehanna, is a wide belt of heavily scored preglacial hills. They have heights above the valley bottoms of 400 to 600 feet, their irregularities have been smoothed by glacial erosion and glacial filling and these vast rock domes or ellipsoids veneered with a generally thin cover of till. These might well be taken as the type of the drumloid and they are as different from the true drumlin in structure and size as they are like it in form. But for the till veneer we should call them roches moutonnées and it is obvious that these bare rock forms may grade into those of the drift-mantled drumloid.

In the southern halves of the Amsterdam and Fonda quadrangles there is an impressive exhibition of drumloids in great variety of shape and material. In general they are elongated and are appropriate to the descriptive phrase "linear topography," as used by Chamberlin in his classic exposition of forty years ago. The hills are low, or low in relation to their length, and lie in an east by west direction. They may be largely of drift and thus approach the true drumlin. They may show veneers on preglacial hills and so approach the central New York type. They may consist largely of shales and shaly sandstones which have been carved into the drumlin shape by the erosive action of the glacier, which has finally plastered them with till. They are therefore combined products of glacial sculpture and glacial modelling. When the rock basis was carved the erosional force was in the ascendancy. When the veneer or a more massive cover of till was laid on, the movement had weakened or the glacier had thinned and the depositional tendency prevailed.

We may here have all gradations between the drumlin, pure and simple, and the drumlin with a rock nucleus, or the drumloid which is nearly all composed of soft rock. It ought to be added that in the last case we do not know to what degree the carved base of the drumloid represents preglacial erosion. Such hills consisting mostly of carved rock Fairchild has called "rocdrumlins." We prefer to retain the terms "drumloid" and "drumloidal" because the shapes and composition are so varied, because there are all gradations in the proportions of drift and rock, and because the term "drumlin" belongs to a hill of accumulation and seems less appropriate therefore to a hill mainly shaped by glacial erosion.

It is impossible to give the relative importance of these varieties in our region as it is wholly rural, sparsely populated and there has been little occasion to make excavations.

Midway between Scotch Church and Mariaville a cut in the roadway crossing one of the long drumloids shows shale rock in place nearly to the crest. South of Mariaville the drumloids are very steep in their side slopes. Roads running directly across a series of them are difficult to travel, slopes of 15° to 20° being common. Long and narrow bogs in many cases run between adjacent drumloids. Good samples of these forms are about Princetown, the church and cemetery being on the south slope of one of them.

The existence and form of Mariaville pond depend upon the drumloid trends of the vicinity. This body of water is one and one-fourth miles long from east to west, lying between drumloid

2

hills. Here flowed the outlet of Featherstone lake, a small natural lake lying to the southward on the ridge between the Mohawk and Norman kill basins. About the time of the Revolutionary War this outlet was dammed for the erection of a grist mill by James Duane, owner of extensive lands in the region of the present Duanesburg. He was a member of the Continental Congress, and of the constitutional convention. The outlet of Featherstone lake had made a small gorge about 20 feet deep and thus facilitated the building of a dam. The dam was renewed and the level raised at various times. Now there is no mill, but the State stocks the pond with fish. (Personal information from George L. Peeke of Mariaville.) The shores have now become a summer resort. Figure 26 shows the lake at its eastern end.

One can hardly run amiss of these elongated hills anywhere in the southern half of either the Amsterdam or Fonda quadrangles. It is difficult to include complete profiles of these long drumloids in a photograph, but the reader will find parts of such profiles in figures 25 and 26. An inverted canoe or racing shell would represent such forms, according to their length as compared with their width. The drainage pattern conforms in a striking way to the disposition of the drift. The rock structure in the two quadrangles should give us dendritic drainage patterns, the main streams and their small affluents leading to the north or south in a digitate manner. We find instead a prevailing east or west flow of the minor or head streams. With an entirely different cause or condition, we get a resemblance to the trellised drainage of some mountain regions. Figure 14 shows a section of the Fonda quadrangle with the drainage in heavy lines. Outside of the area here shown, these waters find their way northward to the Mohawk or southward to the Schoharie and Cobleskill creeks.

We must now observe that this belt of glacially shaped drainage extends far westward beyond our area. In the Canajoharie quadrangle north of the Montgomery county line, the prevailing topographic axes are parallel to the Mohawk river, with a west-northwest direction. The same trends of hills and stream reappear on the Richfield Springs quadrangle, north of Warren and Richfield Springs and in a striking manner about Jordanville. The same conditions continue as far west as Cedarville and Cedarville Station. It will be at once inferred that this westward extension of linear forms will be found significant in relation to the extent of the Mohawk lobe.

There is a further significance in the fact that we find the long, low drumloids prevailing in the Amsterdam, Fonda and Canajoharie

quadrangles, and the true drumlins developing in the Richfield Springs and Winfield areas. This contrast as we go westward points to the greater thickness and moving power of the Mohawk lobe in its eastern parts than in its western section, where it was thinner, narrower and more remote from the vigorous push in the Hudson-Champlain-St Lawrence valleys.

## GLACIATED ROCK BENCHES

The surfaces of drumlins and of rock hills of drumloid form are in many cases fluted or show what we may call ellipsoid moldings. Where glaciated hills are built of horizontal beds of sedimentary rock the designation "rock benches" becomes appropriate. Such hills may have developed benches by the preglacial weathering of the more and the less resistant strata. In that case the overriding glacier smooths off the angles and frequently develops the elliptical profile. Or the glacier itself may be wholly responsible for the differential erosion of the variant beds. These benches may be covered with soil and drift or they may show more or less exposed ledges of the bed rock. It is obvious that these benches are closely related to the drumloidal forms described in the last section. This relation includes both the shapes, the structure and the agent producing the forms.

Conspicuous examples occur on both the Amsterdam and Fonda quadrangles, especially in the southern parts of both areas, where the edges of sandstone beds, bevelled off by long ages of preglacial erosion, face the valley and make up its higher slopes.

We first note, however, an example north of the river, on the north slope of the hills south and east of the village of Glenville (fig. 27). Benches are strongly developed on the north slopes below the Princetown triangulation station, also in the north slopes of the hill Adebahr, where the fluting is conspicuous but the fields are beautifully green and fertile. Other examples are south and west of Scotch Church and on the hills west of Minaville, where the westward moving ice would crowd against the north-facing slopes. Many of these benches are found on the steep slopes of Schoharie creek in the towns of Glen and Charleston.

Figure 3 shows the profile of such benches on the great hill northwest of Burtonsville, as seen from the northwest. These strong benches, having heights of 40 to 70 feet, are on the slopes of a short valley rising westward, one mile north of Burtonsville. Similar rock benches are well seen at Carytown, with escarpments of 10 to 30 feet, and the bedding floor left very smooth. There is in some places a

dip slope from the top of one escarpment to the base of the one above it, with obstructed drainage in the trough. Such a swamp is found one mile west of Carytown and another a mile farther west, each in an angle south of the intersection of two roads.

Further examples with scoured shelves of drumloid shape occur near Charleston, also on the slopes between Esperance and Sloansville, and on the southwest slope of the valley leading from Sloansville northwest toward Charleston Four Corners.

We may perhaps safely say that these linear, or axial lines, due to glacial movements, whether seen in the drumlins, drumloids or rock benches in the field, or on the contoured map, are the most widespread feature in the area which is the subject of this study.

Figure 3 Profile of the great hill northwest of Burtonsville. Slightly dipping sandstone beds benched by strong glacial action and slightly covered with till. Seen from the northwest.

## THE LIMITS OF THE MOHAWK GLACIAL LOBE

To determine with precision the extent of the Mohawk ice would require much detailed study outside of our area, in regions lying southward and westward, where only general observation has been possible. We can, however, assure ourselves with a fair degree of security as to the general outline of the belt in which a westward moving body of ice was dominant.

We can not better enter on such a discussion than by reproducing the diagnosis which, with keenness of perception, was made by Chamberlin more than forty years ago, concerning ice movements in eastern New York. He suggests:

> Massive ice currents having their ulterior channels in the Champlain valley on the one hand, and the St Lawrence on the other, swept around the Adirondacks and entered the Mohawk valley at either extremity, while a feebler current, at the height of glaciation, probably passed over the Adirondacks and gave to the whole a southerly trend (Chamberlin '83, p. 360–65).

It does not seem possible even in the light of later investigation to make a better statement.

In Chamberlin's view, ice, rounding the mountain mass on the west, being a branch of the St Lawrence-Ontario lobe, was pushed up the Black river valley, crossed the divide at its head and came down the Mohawk valley to Little Falls. This view of Black river

and upper Mohawk flowage has been sustained by Miller ('09) in his studies of the region. We may now emphasize Chamberlin's suggestion of a "feebler current," crossing the Adirondacks during that maximum glaciation in which the ice flowed across New York into Pennsylvania. This view of the moderate effectiveness of the Adirondack flow is sustained by various later observers and it is emphasized by the fact that there is a difference of opinion as to whether the ice ever rose above and crossed over the higher Adirondacks summits.

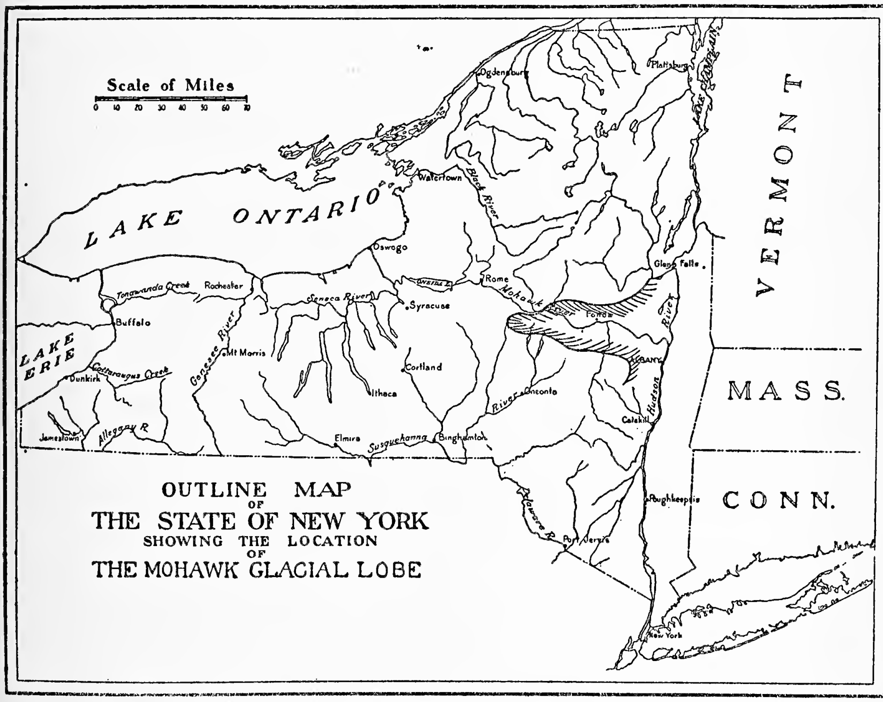


Figure 4 Map showing the location of the Mohawk glacial lobe.

We do know therefore how soon or to what degree the southwestern flow diverted and controlled the early westward flow through the Mohawk depression. We can not be sure that the massive and thick ice moving from the east did not continue to exert effective pressure towards the west and control the movement at least of the bottom currents in the Mohawk region.

In like manner we may surmise that in the waning of the ice, the Adirondack flow weakened rather rapidly and left the Mohawk un-

hindered by its thrust. In any case we know that the Mohawk lobe pursued its work freely for a long period, for this is fully demonstrated by the sculpture and modeling of the land forms as seen in our four quadrangles. We have also given some evidence that Mohawk ice was effective later than the Adirondack ice of the Sacandaga valley.

We have seen that south of our area in the Berne and Schoharie quadrangles and westward, the flow was to the southwest. We can not be sure without further study that these gravings represent the maximum flow from the Adirondacks. They may mark a fanning out of the Mohawk lobe, that is, an axi-radiant activity exercised on its southern side. If the latter is true, the southwestern maximum flow gradually changed to the axi-radiant flow as the ice melted from the great plateau which stretches southward.

In a preliminary report dealing especially with the region south and west of our area, the writer made the following general statement ('10, p. 18) which he now sees no reason to change:

The designation, Mohawk lobe, is of somewhat indefinite application, because the lobe was a part of the waning ice sheet and there is no complete boundary so marked by topographic features, glacial or otherwise, as to create a sharply definable stage deserving this name. Certain features, nevertheless, point to a reasonable differentiation of a glacier within the Mohawk Valley, and overlapping to some distance upon the headwaters region of the Susquehanna.

The same preliminary report gives the following data concerning the southern border of the Mohawk glacier:

On the south the place of bifurcation between the Hudson and Mohawk lobes may be confidently placed at the northern end of the bolder development of the Helderberg escarpment, in the Berne quadrangle, west and southwest of Altamont. This was inferred from an inspection of the contours of the map and is abundantly borne out in the field. [At a later time before seeing the author's preliminary notice, here quoted, Professor John L. Rich ('14) made a similar interpretation of the topographical maps.] In the southeastern parts of the quadrangle the movement was south. In the northwestern section the direction was nearly west, and in the central and southeastern parts around the village of Berne, the direction of striae is intermediate. There is a sharp alignment of drumloid forms in the east and north which does not prevail in the intermediate, or southwest direction, pointing to the more prolonged and heavy scorings of the Mohawk and Hudson lobes.

Following, and also taken from the author's earlier report, we have the rock records of one place in the region of divergence:

About one and one-half miles west of Altamont the exposed slopes which were subject either to Hudson or Mohawk movements, show interesting striae ranging from S 10° E, to W. On one surface

are striae S 5° E crossed by another set having the direction S 30° to 35° W. Another surface has two sets, one S 5° to 10° W, the other west. These records point to an alternating or conflicting control at the very point of differentiation, as determined by the strong northward end of the Helderberg front.

Going westward, the same preliminary report has the following statement as to a possible belt of moraines marking the southern border of the lobe. We must regard this statement only as tentative and suggestive:

There is, however, a significant development of moraines which may in a general way mark the southwest border of the lobe, and may probably be contemporaneous with the Gloversville moraine. These moraines occur near the headwaters of Cobleskill creek near junction with the Susquehanna; along the lower sections of Elk creek valley and Cherry Valley, and along the Susquehanna from Cooperstown to Portlandville. It is significant that a day's drive among the strong hills between Cooperstown and Westford led to the finding of but one locality of striae, showing a remarkably continuous sheeting of ground moraine for such topography.

The possible inference from such an area of massive drift in this situation is that it may be a latero-terminal product of the Mohawk glacier. If the last glacial activity on this northern edge of the high plateau grounds was that of the maximum flow over the state, we might expect these uplands to be more or less denuded of drift. The subject needs to be cleared up by detailed field observation.

The moraines above noted could hardly mark the continuous south edge of a coherent Mohawk glacier, but may have been deposited at the ends of still active valley tongues protruding from the Mohawk trunk ice. They would be like the Finger lake extensions of Ontarian ice, or those long extensions of central New York ice up the Oneida, Oriskany and Sauquoit valleys. These more western ice extensions, however, reached only to the vicinity of the southern water partings, while some of the ice tongues here named stretched well over the Mohawk-Susquehanna divide southward.

On the north side of the Mohawk lobe we have traced a well-defined border nearly across our two northern quadrangles. The possible westward extension of this moraine awaits determination by study in the Lassellsville and Little Falls quadrangles. The section on the interlobate moraine has a brief reference to some morainic belts in these areas.

Whatever obscurity remains as to the borders of the Mohawk ice, no one who observes the striae and the drumloid and linear forms of the axial belt can doubt its presence and vigorous action.

These have been outlined but may here be again summarized for the quadrangles which are wholly or in part south of the Mohawk river. We have the southern parts of the Amsterdam and Fonda areas, the Canajoharie area southward nearly to Sharon Springs, the Richfield Springs quadrangle to Springfield and the village of Richfield Springs and a well-developed area in the northeastern quarter of the Winfield quadrangle. The western limit is around Cedarville a few miles southeast of Utica. West of this locality the dominant lines of the topography run north and south.

If one stands on the high points of the Cherry valley turnpike between Sharon Springs and Cherry Valley, he will command a remarkable view of the deep and wide Mohawk gap. Almost as from mountain heights he will see the fields and forests of this great valley, with a long and rugged Adirondack horizon far to the north. The more assured field of Mohawk glaciation is plotted in figure 4.

## PROOFS OF WESTWARD MOVEMENT

The axi-radiant pattern of glacial striae in the valley admits of no other interpretation than that the ice moved from east to west. Many years ago the present observer reported from a locality in the east end of the city of Amsterdam a graved surface from which a thin

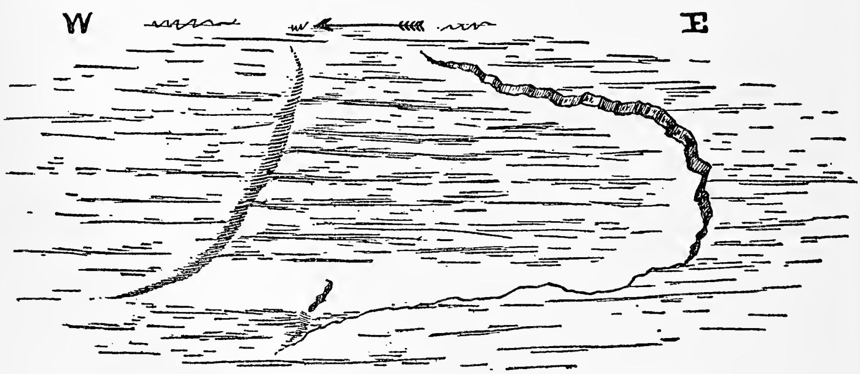


Figure 5 Striated surface of limestone at Amsterdam.

slab had been plucked, with such relation to the scar on the bed rock, that only a westward moving force could have dislodged it (Brigham, '98, p. 194). Figure 5 is a reproduction of the diagram there used.

The east by west striae and linear forms around Cedarville head against a district of north and south lines, showing that two ice currents of differing sources and directions came into conflict with each other in central New York.

We have also noted the trailing out westward of drumlins and drumloid forms and the fact that a good number of drumlins show morainic and bouldery surfaces on their lower slopes at their eastern ends. These conditions also are corroborative of the westward movement.

The same conclusion is enforced by certain facts in the distribution of erratics. If the glacier had made, in its most effective stage, a direct course across the Mohawk valley from the Adirondacks, the boulders would have been both larger and more numerous in all parts of the valley. We cite the paucity of erratics between Johnstown and Fonda and west to Sammonsville, also in the belt of territory from Minaville to Mill Point. We can be sure that almost everywhere in our region, with an Adirondack flow predominating, the Precambrian boulders would have been much more common.

It may be added that in sections of till west of Hoffman Ferry are many boulders plucked from the uplifted and exposed rocks of the Hoffman fault.

One of the most convincing evidences of westward movement is found in the depositional and sculptural activity of the glacier in crossing the Schoharie valley. Here we quote from a preliminary report by the author ('07, p. 23):

> A still more striking confirmation is found in connection with the Schoharie valley. On the east side of the lower Schoharie within this district, the drift is a very massive till and outcrops of the bed rock are almost absent. In fact that section of the Schoharie valley from Esperance to Fort Hunter was filled with till to a remarkable extent and the postglacial excavations by the stream have produced a singularly interesting series of topographic forms normal to river action. On the west side of the Schoharie, on the contrary, outcrops of the bed rock are everywhere present, the drift is very thin, ledges and glaciated benches are frequent and the region gives every evidence of having been powerfully scored. These conditions as between east and west are exactly what would be expected from a westward moving glacier, passing over the hills in the neighborhood of Minaville, dumping and filling in the valley transverse to its course and driving powerfully against the edges of the exposed strata west of the stream, cleaning away the drift and giving the whole topography a characteristic glacial expression.

## DEPTH OF THE ICE

We may visualize the Hudson ice lobe over Saratoga Springs, Troy and Albany. On the west diverged the strong movement up the Mohawk valley. The Hudson river at Troy and Albany is at sea level. The plateau about Cedarville, where the Mohawk flow

seems to have terminated, is about 1600 feet in altitude. Whatever thickness the glacier must have had over the Hudson, in order to push into central New York, we may divide into three components, as follows: (*a*) the difference in altitude; (*b*) the total inclination of the surface of the ice within the distance from the Hudson to Cedarville, or West Winfield—about 80 miles; (*c*) the thickness at its terminal or distal end of a glacier which could be active across a hilly region. For (*a*) we have 1600 feet. For (*b*) we will assume a surface slope of 20 feet a mile (compare antevs '28, p. 64, 65), which gives us 1600 feet. For (*c*) we must regard 500 feet as a moderate estimate. This would give us a thickness of the ice of 3700 feet in the Albany-Troy region.

We may take another example that is comparable in magnitude. The Ontarian ice, filling and crossing the Mohawk valley at Utica, rose from 400 feet of altitude there, traversed a plateau 2000 feet above sea and reached southward about 125 miles, from central New York into northern Pennsylvania. Computing in the same manner, we get a thickness of 5000 feet of ice above the present level of the Mohawk river at Utica. It must be remembered that this represents the earlier maximum flow across New York and antedated the Mohawk ice which we now have under observation.

The case is not so simple, however, as the above computations might make it appear. In the first place let us consider the topographic obstacles which stood in the way of the westward movement of Mohawk ice. Most of the territory occupied was ruggedly hilly. At the doorway of the Mohawk there stood, as there stand today, masses of high hills, the altitudes being about 1000 feet and 1400 feet respectively near the Van Etten and Waterstreet triangulation stations, north and south of the Mohawk, in the Amsterdam quadrangle. The imposing valley which now carries out the Mohawk river between these hills, runs athwart the movement of the Mohawk ice, as it was turning westward, and this valley was of little importance in admitting the ice current into the major Mohawk depression.

The same minor rôle was played as we go west, by the narrow and crooked inner trough of the river. It would seem that at a number of points the general Mohawk flow must have sheared across the ice of the sinuous trough below. This involves friction and consumption of the energy by means of which the ice was driven westward. These physical difficulties in the way of a westward flow might require a higher estimate of the thickness of the ice in the Hudson valley.

A further element of doubt is in our assumption of 20 feet as the average surface inclination a mile, which may have been less or

greater, involving in either case a modification of our figures. Taylor ('03, p. 348), in connection with his studies of glacial conditions in the Berkshire region, gives as his conclusion that, "The average slope along the side of the Hudson lobe, regardless of the tongues and reentrants, is something between 25 and 30 feet per mile." If this figure should be more nearly correct than that of 20 feet adopted above, the thickness of the Mohawk ice would be very considerably increased. We see no reason to believe that conditions of flowage could have been more favorable in the Mohawk than in the Hudson valley. Indeed the contrary seems more probably true.

Again, Taylor, considering the Great lakes lobe of the Wisconsin invasion, takes as a base the line running from the northeast corner of the driftless area in Wisconsin to the tip of the ice-free salient at Salamanca, N. Y. The apex of the lobe was in Indiana or Illinois, 400 miles from the base. The base line, from Wisconsin to Salamanca, was 600 miles long. Taylor figures the average descent of the ice surface from base to apex at about 11 feet a mile but says immediately that this is almost surely an underestimate (Leverett and Taylor '15, p. 511).

If now a lobe of such size, flowing over a region mainly of low relief, must probably have had a slope of more than 11 feet a mile, we are making a highly conservative estimate in assuming 20 feet, for, in the Champlain and Hudson-Mohawk region, we have strong relief and valleys with rugged flanks as a zone of movement for the ice.

On the basis of 3700 feet of ice along the Hudson and a westward surface slope of 20 feet a mile, we should find 2800 feet of ice over the river level at Amsterdam. We gain this figure by allowing for the decline of the glacial surface going westward and the rise of the valley floor above tide level. Estimating by the same method, the southern heights of the Amsterdam quadrangle would have carried 1700 feet of ice. When we consider that the glacier moved nearly 50 miles farther west over a rugged region, this estimate seems too low.

We may check our estimates of thickness by going along the track of the Hudson valley glacier northward. The greater body of opinion is that all Adirondack heights, including Mount Marcy, were covered by the ice at its height. Coleman ('26, p. 51, 52) dissents from this view and regards 4500 feet as proved for that region. If there were but 4500 feet so far north, in the height of glaciation there would seem to have been much less in that stage of decline in which the Champlain-Hudson and Mohawk valleys held differentiated

lobes of ice. The thickness of the Champlain ice would not have been enough to allow any slope southward to a 3700-foot glacier at Albany.

Our own problem therefore leads us toward the acceptance of the higher estimates of thickness for the ice of northern New York and New England. Kemp and Alling estimate the surface slope to be 25 feet and they conclude that there may have been 6500 feet in the Ausable region ('25, p. 72). This is the thickness which, with a 25-foot slope, would permit the ice to reach New York City. Acceptance of these figures would give us almost exactly 3600 feet of ice in or near the present site of Albany.

The submergence of the Adirondacks is unequivocally accepted by H. L. Alling (Kemp '20, p. 62, 64). In the reference cited Alling quotes estimates of 8500 to 12,000 feet as necessary to afford a gradient with which the ice could have flowed thence to New York City. Fairchild also holds that the Adirondacks were completely covered. The Green Mountains including Mount Mansfield were submerged by ice currents deep enough to sweep diagonally across the range to the southeast. Submergence is held as unquestionable for Mount Washington by Professor Goldthwait ('25, p. 13).

For further evidence that great depths of ice must have engulfed the Adirondacks, we may return to our estimate of 5000 feet of ice over Utica. Adding 400 feet for the altitude of the Mohawk river at that point we have an ice surface 5400 feet above tide. Utica is about 95 miles from Mount Marcy. Again computing slope of ice surface at 20 feet a mile, we get 1900 feet, or a requirement of ice surface over Mount Marcy at 7300 feet above sea level.

Summarizing now the several conditions relative to the thickness and flow of the Mohawk lobe and its northern source of supply, we note as follows:

The axial length of the Champlain-Hudson-Mohawk ice current from the Champlain valley east of Mount Marcy, by way of the Saratoga Springs-Albany region, to Cedarville, in Herkimer county, is 150 miles.

The altitude of the plateau about Cedarville is 1600 feet.

The thickness of the ice postulated at or near its front is 500 feet.

The slope of the ice surface is taken at 20 feet a mile.

The total slope of ice surface from the latitude of Mount Marcy to Cedarville is 3000 feet.

We require therefore 5100 feet of ice in the middle Champlain region.

This is probably an underestimate because the frictional retardation of a narrow flow through rough country would seem to require

a far greater inclination of ice surface than Leverett and Taylor assume for the Great lakes lobe.

According to the isobases of Fairchild ('18), the post glacial uplift or upward warping toward the north amounts to 250 feet between the Albany region and the mid-Champlain or Mount Marcy latitude. This strengthens our conclusion that very massive ice in the Champlain valley was needed to force a glacial lobe upon high ground in central New York.

If our conclusion as to the thickness of the later ice streams is valid, it forces us to an important inference concerning the ice recession in northeastern New York. The view has been widely accepted that the Adirondack area in the later stages of ice occupation became an island, a sort of gigantic nunatak, nearly free from the invader, but surrounded by active ice.

This view is not tenable if we must have 5000 feet of ice or more in the Champlain valley, while the Mohawk glacier was existent and active. Light is thrown on this problem by an inspection of a relief map of the Adirondack region. Only a small fraction even of its inner and central uplands has altitudes above 3000 feet. Not half of the Precambrian surface is above 2000 feet (Miller, '17, fig. 4). It is obvious that 5000 feet of ice in the middle Champlain region and more than 3000 feet in the middle Hudson valley are inconsistent with ice-free surfaces of any great extent in the Adirondacks.

This view does not destroy the reality of ice streams flowing around the mountain area, but it suggests the diminished activity or actual stagnation of the ice fields that must have remained in Adirondack territory. Here we recall and emphasize Chamberlin's "feebler flow" across the mountains when they were finally submerged. The flow weakened with the progress of the final ablation, much of the ice became stagnant or flowed only in favorable situations. Such a situation was along the Sacandaga at the north border of our area, where the valley offered a low gap leading out of the mountains. Another favorable situation is perhaps found in the North Creek quadrangle where Professor Miller has reported the rather surprising southward alignment of the glacial striae.

In this connection there is especial significance in a summary statement by Dr I. H. Ogilvie ('05, p. 470). Of the Adirondacks as a whole it is stated that "the general direction of ice movement was toward the southwest, that the motion was vigorous among the outlying lower hills, but that among the higher mountains the ice was stagnant in the bottoms of the deep valleys, while at the time of the maximum

extension of the ice sheet it passed over the tops of these filled valleys smoothing the mountain summits. It was further shown that the glacial deposits belonged in general to the time of retreat and melting of the ice, being largely of stratified material."

These statements are quite in harmony with the supposition that as the ice began to wane there was a gradual thinning in the mountains and a progressive loss of activity. At the same time the ice was maintained at relatively high levels, and around this body of ample but decadent ice the valley currents continued to move in great depth and strength. We must not ignore the fact that in all stages of glaciation the Adirondack area was a theater of storms and falling snows and therefore a feeding ground for the ice along the southern slopes of the region. Some contribution of Canadian ice, with added supplies of local origin, and the prolonged preservation of drift-mantled ice in the valleys, helped maintain high levels when vigorous action had been abated in the central areas.

## THICKNESS OF THE DRIFT

The drift is highly variable in amount, ranging from massive deposits on some of the lower grounds to a bare veneer on some higher and more exposed surfaces. There are two great east and west belts of thick drift. Along the Mohawk river heavy deposits prevail on the north side from the Noses to Hoffman Ferry, with a width of one to two miles from the stream. Bed rock may occur at the base of the valley wall, as east of Fonda, at Tribes Hill and at Amsterdam, the drift rising abruptly as a massive shoulder on the north. Sections may be seen where streams from the north lead down to the Mohawk, as above Fort Johnson where the drift is 60 to 100 feet thick. Above Kellogg's dam in Amsterdam is heavy till with some exposures of 50 to 60 feet. Similar conditions appear on the road from Manny's Corners to the river and in the Cranesville gorge. The valley at Cranesville is a preglacial trough, mature at the north, clogged with drift to the south and deeply trenched by the present stream. Most of the fill is on the east side, a massive shoulder, whose drift is 150 feet in thickness, much exposed along the creek. Heavy drift appears in several sections, in the city of Amsterdam and above the electric railway from Cranesville to Hoffman Ferry and beyond.

On the south side of the Mohawk massive drift appears from Fort Hunter to Port Jackson. Yankee Hill cut and other excavations in Port Jackson show very heavy drift. Three miles east of Port Jackson a stream heading on the north of the hill Adebahr enters the

Mohawk. Here is a most impressive gorge, cut 100 feet or more in solid till and marked by many landslips.

Above Pattersonville along the slopes of Sandsea kill, is an enormous mass of ground moraine, left in a preglacial valley leading down to the Mohawk. The till is more than 100 feet thick and rises in great shoulders more than 500 feet above the river.

The second zone of thick drift within our area runs from the escarpment of the Noses fault at Clip hill eastward. It takes in the cities of Johnstown and Gloversville, the areas around Broadalbin and Perth, extends eastward to West Galway and the Amsterdam reservoir, and northeast by Hagadorn's Mills and Barkersville to the eastern edge of the Broadalbin quadrangle. It is the belt of the interlobate moraine already described. One might travel the entire distance of 25 miles and not pass an outcrop of bed rock. If along some roads there were exceptions they would be near some stream. In all this belt our map shows not a single example of glacial striation and this is true northward over the marshes of the Sacandaga and southward well toward the Mohawk river. The masking of the rock surface is, for a region bordered by mountains and plateaus, remarkably complete.

There is also very thick drift along the Schoharie creek from Fort Hunter to Esperance, accumulated in the trough as the Mohawk glacier moved across it westward. A remaining region of thick drift is along Norman kill, eastward of Duanesburg. Two miles east of this village is a great cut along the railway, north of Norman kill. showing heavy till with many boulders. East of Kelly's Station on the south side of the stream are banks of till 60 to 80 feet in height.

In several parts of our area the drift is thin and outcrops are common. This is true along Chuctenunda creek from Amsterdam to Rockton and Hagaman and in the region around Manny's Corners. It is only partly true of the Adirondack areas north of Gloversville, and both west and east of the great southward loup of the Sacandaga river. The drift is patchy in these high grounds—thin here and thick there. Thin drift prevails on the high and rather even surfaces west of the Noses fault from Yosts northward for several miles. South of the Mohawk river in the Amsterdam quadrangle the drift is deep to Scotch Bush and Scotch Church, but thinner to the southward on the sandstone heights which occupy most of the southern third of the quadrangle.

Thin drift prevails on the high ground throughout the southern half of the Fonda quadrangle. It was heavily scored and is almost free of morainic accumulations and is marked everywhere by long drumloidal hills, which show a very constant veneer of drift.

The map does not give a complete showing of rock outcrops or glacial striae. These features appear on the map more often near the roads. The observer is more apt to see them there, and the cuts and rain wash along the highways tend to uncover bed rock surfaces.

Estimates of the average thickness of the drift can be little more than guesses. Considering the important belts of thick deposits in our area, I do not regard 30 feet as an excessive figure, if we imagine all the drift evenly spread over the surfaces of the bed rock.

## ERRATICS

The drift boulders show as usual the predominance of fragments from the bed rocks of the locality. Thus in the vicinity of the Adirondack mountains they are of ancient, or Precambrian types. Toward the Mohawk river, limestones abound in the drift, and on the southern heights of the Amsterdam and Fonda quadrangles sandstones prevail.

The greater number and larger sizes of boulders occur as would be expected in and near the mountain lands in the north of our area. This increase in abundance and bulk can be well seen as one goes out of Gloversville northward and proceeds toward Mountain lake. As far away from the mountains as along the road leading from Broadalbin to West Perth the boulders are nearly all crystalline. Going south from Sacandaga Park along the road west of Tamarack swamp, the boulders are so thick in some fields that one might almost step from one to another. They run in size from three to ten feet, with now and then specimens having dimensions of 15 to 20 feet. Around Barkersville are conspicuous fields of boulders, among many others in the northern region.

One-fourth mile south of Sacandaga Park Station, west of the railroad crossing and extending along the railroad, is a field of boulders which were washed from the till on the west shore of the Sacandaga (glacial) lake. It is such a field of washed erratics as may now be seen on many New England beaches. In the eastern part of Amsterdam between Main street and the New York Central Railway is a field of medium-sized boulders washed out from the local till by the Iroquois waters (fig. 51).

Around Manny's Corners and eastward and east of Hagaman, is a region of thin drift and many limestone outcrops, and limestone slabs are abundant in the drift and many have been built into walls about the fields. The till sections, which are numerous from Fort Johnson eastward to Amsterdam and beyond, show many boulders. This condition may in part arise from the exposures of bed rock of

the Hoffman uplift, lying in the track of the westward movement of the Mohawk glacier.

The erratics are less abundant on the south side of the Mohawk river, although large crystalline boulders occur. Two such fragments, five by seven feet in size, are found by the road a short distance southward from Fultonville. About half way from Mill Point to Glen below the road on a slope facing northeast is a gneissoid boulder whose dimensions are 21, 15 and 10 feet. These boulders could not have come directly south from the Adirondacks athwart the westward flow of the Mohawk lobe. They must have come from the eastern Adirondacks by way of the Champlain-Hudson ice and were then carried around into the Mohawk depression.

Some of the till sections south of the Mohawk show many boulders, as for example rising from the valley level south of Fort Hunter. There are few erratics on the Princetown hills, those present being angular sandstones. On the contrary, the fields show many boulders for two miles north of the church at Duanesburg, one six-foot crystalline being seen. Rather unaccountably we find one and one-half miles northwest of Carlisle, near the Cherry valley turnpike, stone walls with many crystallines, some being of large size. North of Little York, west of Carlisle, is a limestone boulder 30 feet in length.

## MINOR MORAINIC AREAS

Brief reference may be here made to several small bodies of morainic drift, of till or of washed materials. Several of these were sufficiently described as belonging to the recession of the Sacandaga glacier. As appears from the map, patches and belts of morainic till are common on the lower grounds of the mountainous parts of the two northern quadrangles.

Northeastward from Yosts station is a small group of kames between Briggs run and the Noses escarpment. It was a natural position for the retardation and melting of a west-moving mass of waning ice, with stagnation, water action and kame formation. These hills lie at the west end of the Fonda wash plain and are seen from the New York Central Railway.

Small bodies of kames and of till moraine are found on the eastern border of our district, in the southeast parts of the Broadalbin quadrangle and the eastern part of the Amsterdam quadrangle. They seem to be products of recession where the ice had largely retired from the Mohawk valley but was still present in some depth in the Hudson valley north of Schenectady.

An area of kames covering ground perhaps two square miles in extent lies around Glenville. To the east are smaller kame hills, and northward also near West Charlton. It will be observed that from Glenville the Crabb kill leads out over comparatively low ground to Alplaus kill in the Schenectady quadrangle. High hills rise between Crabb kill and the Mohawk river. The lower ground here seems to have admitted an overflow from the Hudson valley ice, a short, broad tongue maintained long enough to make these recessional accumulations. A fairly defined spillway leads southward from these kames into the Mohawk valley trough.

South of the Mohawk river both the Amsterdam and Fonda quadrangles are remarkably free from terminal accumulations. The observer, watchful for such features, is greeted everywhere by the flowing and blending curves of the ground moraine, molded into drumloid forms. Two small areas of moraine till are recognized on the map, near Oak ridge and Burtonsville.

If there were, as may be possible, morainic accumulations, or the ice-contact slopes of kame terraces, along the Mohawk river, they have been almost completely disguised by water-laid drift or cut away by the powerful stream that long swept through the valley.

So far as one may judge from an inspection of the topographic maps and from some field observations, the Canajoharie, Richfield Springs and Winfield quadrangles offer the same types of surface that we have noted south of Amsterdam and Fonda. We are referring to the parts of those quadrangles which were specially affected by the Mohawk glacier.

## SAND PLAINS

The physiographer applies the term "sand plain" to a flat-topped body of washed drift of the nature of a delta laid down in waters which were retained by walls of glacial ice. We have several examples in the Broadalbin quadrangle. We take first a typical form of this nature lying west of the village of Edinburg. It is more than a mile across in any direction and rises from the 900-foot level to a maximum altitude of about 1060 feet. The thickness of the water-laid material is thus 160 feet. Butler creek has cut the sand plain into two parts. Horizontal stratification appears near the top of the plain by the road bridge one mile above Edinburg. The top is very smooth and is bordered by a steep bluff on the south and east. At the base of the bluff is a very abrupt transition to till. The hills to the north and west had become free of ice, and the Sacandaga valley was still clogged with the glacier, which, as it melted on the west,

opened a temporary basin for a small lake, which filled with the wash from the higher slopes. The stream continued to flow across the plain, and has dug the bisecting gorge which the contours of the map very well show.

At the north end of the village of Northville a flat-topped body of washed drift rises 54 feet above the terrace on which the village stands. Apparently the ice occupied the valleys on either side and merged in a common flow over the site of the village and southward. At the south end of the ridge, where the ice streams joined, was a natural place for melting, for an ice-bound pond and for sedimentation.

Another small example has been referred to in our account of the Sacandaga glacier, number 6 of the list of forms on the hillside one mile southeast of Northville (see page 28).

A well-developed marginal sand plain rises a half mile east of the village of Benedict. The plain has been bisected by Hans creek. According to the contours the south section is lower than the one on the north, but the hook-shaped extension at its west end rises toward the north in a way not shown by the map. We have conditions like those at Edinburg, a glacier in the lowland melting on its eastern edge, holding a small body of water between itself and the hills and receiving sediment. The delta extended eastward from its present limit and has been cut in two parts as at Edinburg.

A similar case occurs below Hagadorns Mills, the two sections being separated by Kenneatto creek. In Mayfield village we have morainic conditions with a flat plain stretching south and west. It is not a sand plain built in glacially impeded waters but appears to be an outwash plain in front of the retiring glacier.

It is of interest to compare the altitudes of three of the above plains, each of which has been built and later bisected by a small stream. The Edinburg plain rises 1060 feet, or possibly 1070 feet. The Benedict plain is at 860 feet and the plain below Hagadorns Mills stands at 980 feet. Here are variations aggregating 200 feet or more within a distance of ten miles. The altitudes are not serially arranged, and if they were the northward warping is insufficient within the distance to bring them into harmony. The inference is that the plains indicate local conditions and are not referable to a large body of water.

## GLACIAL LAKE SACANDAGA

This name is given to a body of water which occupied the depression now known as the Great Vly and extended over many square miles of land which is now outside of the marshes and remote from

them. The water of the lake was held in place by the massive drift in the region of the interlobate moraine and by the receding ice of the Sacandaga region in the vicinity of Batchellerville and Conklingville. The deposits of the Vly are sediments of this lake overlain by accumulations of vegetable remains.

The most important and best formed delta of our region of study was built in this lake by the waters of the Sacandaga glacier issuing near Northville. Most of Northville village stands upon a flat table which is a fragment of this delta. The delta can be traced about a mile north of Northville, heading against a great recessional moraine. South of Northville it has been dissected by the river and partially removed. There are remnants on the east side of the Sacandaga, as at Northville, but the preserved delta surfaces are mostly west of the river.

One mile northwest of Northville the river road on the west bank rises to the head of the delta at an altitude of 800 feet. The surface material to a depth of three or four feet is coarse and bouldery such as we should expect to find in this situation. North of this the road cuts through higher gravels and sands of kame structure. Across the river is a massive group of kames showing washed materials to the top, which is 125 feet above the river. There is a fragment of the delta head on the east side of the river, reaching northward from the site of the village. Thus we have on both sides of the river a strong moraine, which was a recessional front of the ice and is a definite northern limit of the outwash at that stage. This group of kames is not adequately shown on the topographic map.

The terrace upon which Northville stands is very smooth and is above 780 feet, with the Sacandaga river on the west and a small stream on the east. The Northville terrace is about one-half by three-fourths of a mile in extent. Structure sections on the edges and slopes of this platform show sands and pebbly gravels, sometimes ill sorted, sometimes well stratified. In all the sections seen, however, the stratification is approximately horizontal. A narrow remnant of the delta extends southward about one and one-half miles on the east side of the river.

West of the river the delta forms the recreation grounds of Sacandaga Park. Thence it extends southward four miles, its southern border being as far south as the village of Cranberry Creek, but not reaching so far westward. At Osborn Bridge the delta is 25 feet above the flood plain of the river, its surface is very flat and the material is fine silt. The road from Northampton to Cranberry Creek crosses the south end of the delta for about two miles. At one

point it passes over a small hill of till which is inclosed in the delta sediments. Other till belts lying partly in the delta silts are found toward Cranberry Creek and near Osborn Bridge. The southern part of the delta has an altitude slightly over 760 feet.

The greater part of the delta, or its upper beds, has been removed by the river for a distance of three miles from Northville to Osborn Bridge. For two miles south of Northville the river has cut away the delta silts and made a flood plain averaging a mile in width. South of this is a quadrilateral area about a mile in dimension which is an abandoned flood plain, now a river terrace. It is uneven and bouldery in parts. This is due to the sorting of the delta materials by the river currents. There is a well-defined back channel of the river at this earlier and higher stage.

It is possible that the lake included a body of shallow water where now Tamarack swamp is found. This appears if we observe that lake sediments rise to about 800 feet in Sacandaga Park and that Cranberry creek issues from the swamp at or near 780-foot level. Thus the higher land running from south of Sacandaga Park to the village of Cranberry Creek may have been an island.

Kenneatto creek comes out of the hills a mile and a half east of Munsonville. We follow the creek almost to Vail Mills and turn westward up the small Skinner creek to its upper course on the edge of the Gloversville quadrangle. West of this headwater a small stream flows west-southwest to the Cayudutta creek in Johnstown. The divide between these two small streams appears to have been the outlet of Lake Sacandaga (fig. 28).

The altitude of this water parting is about 780 feet. West of it for one and a half miles is a well-defined channel 10 to 15 rods wide, flat, boggy, with well-defined edges and bearing in some places washed-out boulders (figs. 29 and 30). The present stream is quite inadequate to these results and indeed does no appreciable work. Farther down, the valley is narrow, the old channel less well defined and the fall is greater. The lower slopes of the drumlins look as if eroded a long time ago, so that the steep cut banks are softened and subdued. This result would have come about rapidly and early, considering the sandy nature of the till in this region. If the evidence of a fairly large stream flowing to the Cayudutta in glacial time is not striking, the conditions do not forbid that supposition. We have to consider also that glacial "floods" so called, carrying water from melting glaciers, may be torrential but are not so wide and deep in fact as they have been in the popular imagination. From the divide past Vail Mills to its entrance on the Vly, near Munson-

ville, the valley was filled with a narrow and irregular southward arm of the lake waters.

The discrepancy between the higher levels of the delta near Northville at about 800 feet and the outlet at a little under 780 feet is quite precisely accounted for by the differential uplift or warping which has affected the northeastern region since the time of Pleistocene submergence (Fairchild, '18, pl. 3 and 9). Including the southern arm which led to its outlet, the lake was about 15 miles long. It came into existence as the front of the ice receded northward from the interlobate moraine and grew in extent with the different stages of recession, until a long stand of the ice front was made in the valley above Northville. In similar fashion a long eastern arm of the lake extended to the ice front indicated by the moraines north of Edinburg and Batchellerville.

The lake reached westward toward Mayfield in a shallow bay, covered most of the Munsonville series of morainic hills as already noted, and swept past North Broadalbin, Benedict and Northampton on the east. It is of peculiar interest that this lake, held by a glacial dam reaching toward Conklingville, is soon to be essentially renewed by a power dam placed on the site of that preglacial divide in the mountains. The facts concerning this new development belong in a later section devoted to geography. In concluding this sketch of Lake Sacandaga, we refer the reader to Fairchild ('12, p. 35 and 36). On pages 35 and 36 and in the map, plate 8, matters pertinent to the foregoing sections are treated. The author regrets that he is unable to concur in the conclusions of Professor Fairchild as expressed in the text and the map. Some further reference to the problems involved will be necessary in our later discussion of the history of Mohawk glacial waters, in so far as the phenomena of our area of study may throw light on that history.

## LAKE SCHOHARIE

An interesting deposit of lacustrine sands and clays is found along the Schoharie creek, beginning at Esperance and extending up the valley for some miles in both the Fonda and Schoharie quadrangles. The cause is found in the dumping of till and filling of the valley to considerable depths between Esperance and the Mohawk river. This barrier lay in great strength between Burtonsville and Esperance. At the great spur projecting into the valley from the east above Burtonsville the cliffs are 200 feet high, about 50 feet at the base being cut in bed rock. Lake Schoharie must have

stood at least as high as 700 feet above tide, behind the till dam, and must have extended about 20 miles up the Schoharie valley from Esperance.

The lake deposits reach 680 feet near Sloansville, where Fly creek enters the main valley. There is apparently a well-marked delta belonging to this lake above Central Bridge and along the valley toward Cobleskill.

There can be little doubt that there was a glacial Lake Schoharie held by a receding ice barrier as the glacier waned in the upper valley. The lake already described would have been a successor to this, as it lay behind its till barrier in late glacial, and in postglacial time. Fuller knowledge of both the glacial and postglacial phases of Schoharie waters requires detailed study outside of the field of this report.

## DIVERSION OF THE SACANDAGA RIVER

The Sacandaga river makes an abrupt turn at Northampton and flows northward past Edinburg, crosses the Stony Creek quadrangle, passes through a gorge in the mountain at Conklingville and enters the Hudson river at Hadley and Luzerne. The river thus shuns the relatively low country between it and the Mohawk and returns northward to cross a mountain range. The 720-foot contour line of the map crosses the river one mile below the Northampton bridge. Thence the descent is but 20 feet to Conklingville, a distance of about 15 miles.

C. M. Sumner of Edinburg informed the writer that in flood time the drivers had trouble to prevent the logs, which were on their way from the Adirondack forests, from going off into the big Vly. The current is sluggish and the flood plain is at times a swamp from Northampton to Conklingville. Mr Sumner also mentioned that Sir William Johnson was said to have used a canoe in parts of the Vly where boating is not now possible.

The idea of a shift in the lower courses of the Sacandaga and the Hudson does not wholly belong to physiographers. On the writer's mention of these probable changes (the conversation was in 1906) Mr Sumner said he had thought of that theory. A farmer harvesting buckwheat on the flood plain below Northville voluntarily suggested the former existence of a lake, and had thought about the possible change of course by the river. The difficulty of tracing an idea to its sources is illustrated here, as also in the shrewd guesses by Timothy Dwight and other early travelers, as to the origin of

Niagara, of the gorge at Little Falls and other scenic features of the State (Brigham, '14).

The destructible sedimentary rocks lying between Northampton and the Mohawk river must have so yielded to the processes of normal degradation as to carry the Sacandaga to the Mohawk. This development was interrupted and an anciently established régime revolutionized by glacial changes, which led to the deposition of our interlobate moraine and left along its course a mass of drift which dammed the preglacial valley and sent the river back to cross an old col in the mountain range at Conklingville (Miller, '11, p. 54–56).

In a precisely similar manner the preglacial Hudson river flowed southward by Corinth, through Greenfield and west of Saratoga Springs. It was dammed by morainic barriers south of Corinth and Palmer and sent toward the sea across the mountains by Spier Falls, Glens Falls and Fort Edward (Miller, '11a).

The upper courses of Hans and Kenneatto creeks in the Broadalbin quadrangle are suitably aligned to join a trunk stream leading southward to the Mohawk. They now swing abruptly northward near Benedict and Vail Mills. Professor Miller in the first reference has given a map of the probable glacial drainage, in a normal dendritic plan. The map shows various streams, including one flowing southward from Batchellerville, the two above mentioned and others which join the trunk current of the Sacandaga on its way to the Mohawk.

It should be said, however, that we can not be sure that we have at any point in their courses the preglacial valleys or axes of movement of Hans and Kenneatto creeks. Glacial changes, especially in massive deposits of drift, may have completely reorganized the subsidiary as well as the trunk drainage of the quadrangle.

Where did the Sacandaga river enter the Mohawk? This question is of special interest to the physiographer who studies the quadrangles here under survey. Our knowledge of the depth of the drift and of the position of the bed rock surfaces does not now admit of reaching a secure answer to the question.

We do not know the depth of land waste to the bed rock in the great Vly. Thence to the south border of the Broadalbin quadrangle the drift is very heavy. We should expect to find the preglacial passage to the Mohawk across the northern section of the Amsterdam quadrangle. But here we encounter too frequent outcrops of the bed rock to admit of a spacious valley which might now be filled with drift. The valley entering Cranesville, minus its drift filling, is spacious but reaches bed rock levels of 600 to 700 feet of altitude

within two miles of the Mohawk. Unless, in conditions now unknown, the Mohawk has deepened its channel by erosive action since the diversion of the Sacandaga, we should need to find the Sacandaga channel gradually for many miles approaching grade with the Mohawk. This is not true north of Cranesville.

It is conceivable that the Sacandaga found a way to the southeast through the Glenville gap, but apparently bed rock under the Alplaus kill in the Schenectady quadrangle is found at too great an altitude to favor this alternative.

There remains the possibility of an outlet by way of Johnstown and west of Fonda where now is the Fonda wash plain. It is possible that in the very ancient faulting which produced the escarpment running toward Northville the down-thrown block may have had such an attitude as to force the lower Sacandaga westward toward the line of dislocation. These alternatives are quite of a conjectural nature, but they do at least suggest the opportunities of further study.

The writer of a recent volume of Mohawk valley annals thinks that "probably the Cayudutta or some similarly located stream was one of the ancient water courses which drained the southern Adirondack slopes." He mentions the Caroga, East Canada creek, and West Canada creek, making no reference to the Sacandaga river, but we have here another of those blind guesses which may approach the truth (Greene, '24, p. 106).

## WATER-LAID DRIFT DEPOSITS ALONG THE MOHAWK RIVER OF ALTITUDES BETWEEN 400 AND 480 FEET

One of the most persistent features of the inner trough of the Mohawk river is in the existence on its borders of bodies of stratified material. They consist of sand, gravels and clays in deltalike forms in reentrants of the valley side, and of shoulders of stratified drift along the upper slopes of the valley walls forming narrow platforms against the till slopes that rise beyond them. These deposits have surface altitudes of between 400 and 500 feet, but range for the most part from 440 to 460 feet.

These deposits with their striking accordance of levels were noted and some of them briefly described by the writer in an earlier paper ('98). In the paper to which reference is made, it was observed that deposits of this character and altitude prevail between Little Falls and Schenectady. Later and more detailed observation reveals more examples than were recognized in the paper cited.

The glacialist would expect to find these flat-topped masses of stratified drift which flank a river showing morainic or ice-contact

slopes, thus giving us kame terraces. Such slopes are absent from these forms. Likewise we do not find the lobate borders or fringes which we should expect if the deposits were deltas built into an extended lake occupying the valley. Both the kame terrace and the delta may here be present though the characteristic slopes do not exist. We have but to recognize the presence through a long time in this valley of powerful currents of water, here escaping eastward from vast and changing glacial lakes in the Laurentian basin.

At many points sections of till appear on the lower valley slopes, below the cover of washed materials. The washed drift would normally mask the valley side to the bottom. It has been persistently and powerfully cut away by streams, or by slipping in standing water, leaving in places slopes that are almost precipitous and quite unsuited to a mature valley, whether that valley has or has not seen glacial occupation.

The most westerly area on the north side of the river extends from the northern Nose to Fonda. It thus fronts the river for five miles. The northern end of the deposit is a mile south of Sammonsville along the Cayudutta. As may be seen from the map, the deposit is triangular in form and is continuous through most of its extent but is much dissected along its northeastern border by the Cayudutta and its tributaries. The continuous area west of the Cayudutta is locally known as the Sand Plains. The surface of this section is very smooth and marked by soils of a fine and silty nature.

Much of the deposit has surfaces at about 440 feet. The altitude rises slightly against the hill bases. Against the Noses escarpment the 460-foot contour marks very closely the upper limit. Its border under the escarpment has been changed through removal by the streams descending the slope, and by wash from the till mass above. Thus the contact with the slope is obscured.

At the Roman Catholic cemetery north of Fonda the surface materials are loam, with gravel below three feet. The surface is very flat on both sides of the road. The plain here reaches above 460 feet. At the head of the deposit below Sammonsville we find a very flat and smooth surface 27 feet above the road. The Fonda cemetery and the ground eastward show yellow silt. One exposure in the cemetery is quite clayey, and across the road from the cemetery west the fields are flat and loamy without stones.

We have clearly a deposit in standing water, which in form and relations seems to be a delta of Cayudutta creek made either in an extended Mohawk lake or in a more local pocket by the side of an ice tongue. The case is not however quite so simple as the statement would imply.

On the south or river side of the plain, midway between Yosts and Fonda, is a 40-foot section showing sand and gravel, some of it coarse, with large and subangular cobblestones and small boulders. The beds alternate in coarseness and in places show a moderate dip away from the river. That during part of the period in which the plain was building there was an ice tongue and the feeding of waste from the south is strongly suggested.

In the northern part of the plain if we had a simple delta we should not expect such a prevalence of silt. This may be partly accounted for by the flow from the glacial Lake Sacandaga. The coarser materials discharged into that lake would be found under the marsh deposits of that region, and the silts alone would reach the Mohawk trench. This feature of the outlet flow and the consequent lack of the tools of erosion may account for the imperfect development of the outlet channel near Johnstown.

We may now call attention to a condition that obtains in many localities as we go eastward. The map shows areas of till occurring under and at the edge of the wash plain west of Fonda. The till also appears at the base of the slopes as we go up the Cayudutta valley; also east of the village of Fonda for some distance. The washed mantle of the valley sides has been cut away, exposing the basal masses of till.

In this connection we may observe the hill rising steeply within the village of Fonda, around which runs an old channel of the Cayudutta creek. The hill is known as Tayberg, traditionally so named because early settlers found there an herb which they used for tea. The hill is not smooth and drumloid as indicated, but has a knife-edge crest from north to south. The body of the hill is of laminated clays near the base with sandy silts above. There is till at the base on the north. Steep sides and frailty of materials have caused several landslips about the hill.

On the south side of the river southward from Randall and adjoining Yatesville creek and Allston creek are two shelves at 400 to 440 feet that look like deltas. They are more terracelike and flat-topped than is shown by the contours of the map. The material seen looks like an oxidized till but lacustrine sediments may have been overswept by torrential wash from the steep slopes to the southward. We need to remind ourselves of the swift and effective erosive action that took place on bare slopes recently freed from ice.

From Fultonville, which is across the Mohawk river from Fonda, a compact body of washed drift stretches eastward almost to Schoharie creek. It is five miles long and varies in width from one to one and one-half miles. It is bisected by the valley of Auriesville

creek, and upon it, near that village, stands the well-known shrine erected in memory of Father Isaac Jogues, missionary to the Indians, who suffered martyrdom here in 1646.

To this body of washed materials we give the name Schoharie Wash Plain. We hesitate to call it a delta of the Schoharie creek although it may be partly of that nature. It would seem to be in relation with small shoulders of washed material at 400 to 420 feet south of Fort Hunter, and with similar features of considerable extent east and west of Tribes Hill on the north side of the Mohawk river.

Projecting from the silt cover east of Auriesville is a high spur of till reaching to Schoharie creek. About one mile above Auriesville following Auriesville creek, on the east side of the stream, the cliff shows about 70 feet of till, 40 feet at the base and the upper parts oxidized. Above the till are two to three feet of silt. We thus see that the lacustrine sediments covered a strong till ridge, earlier deposited, and it is evident that the lake beds and the till ridge have been vigorously cut away by the Schoharie creek and by the Mohawk river.

Going south from Fultonville, one-fourth of a mile up the hill, at the intersection of two roads, an excavation for a hydrant showed four feet of laminated clays at an altitude between 400 and 420 feet. West of the road intersection a remnant of the water plain terminates against the hill slope. East of the above-mentioned fork in the road is a large sand pit of recent and current working. Here in a fresh exposure are delta sands showing topset and foreset beds, indicating entrance of water from the west. It is not thought, however, that this explains the great body of the deposits which widens eastward and extends several miles along the river. As we go southeast on the road toward Glen we are on or slightly above the plain at various points. At the Fultonville reservoir the material is till, at 480 feet. South of the next road intersection stony till occurs at 500 feet. A little farther south, at 460 feet, the surface is very smooth and flat and the material is clay without stones. As we cross Auriesville creek, still going toward Glen, a few rods north by the road we find several feet of fine clay at 440 feet.

We thus find an upper limit of 440 to 460 feet where the plain abuts against the southern hills.

Three miles up Auriesville creek from the south edge of the plain, and two miles southwest of Glen, by the side of the road the creek has made a 40-foot section, showing at bottom 20 feet of blue till, then several feet of laminated clays, and above, an oxidized till with strings and pockets of silty clay and loam. The altitude is

460 feet and we may have a remnant of sediments deposited all the way up to this point and later largely removed by the stream. We have a good illustration of lake work in front of a glacier retreating from a highland area.

It will be observed by consulting the map that terrace levels of washed drift occur at and west of the village of Tribes Hill, the approximate altitude being 440 feet. Here also the till underlies the silt though not visible at all points along the river base of the terrace. An outlier of this area of lake sediments appears across Danascara creek westward. There, over till, are 15 feet of dark blue, laminated clays and on these are six to ten feet of yellow sand. Danascara creek without doubt entered the Mohawk river near Tribes Hill in preglacial time. Drift blockade at that point turned it southward and it has in its new and shorter course cut through bed rock and made the gorge above the DeGraff mansion on the Fonda road (fig. 60).

Eastward from the Tribes Hill area the Antlers Country Club and golf links occupy a similar terrace. Along the electric railway from Antlers station to the brook three-fourths of a mile eastward is an almost continuous section of heavy till, with many glaciated pebbles and boulders. The grounds lie on a flat-topped ridge extending from the creek on the west to a field on the east, which bears an ancient cemetery of the Kline family. The flat top of the ridge is 20 to 30 rods wide and its altitude is about 460 feet. It is composed of washed drift lying on the till.

On the north is a swamp covering the divide between two brooks. North of this swamp is a fine drumloid hill, whose slopes bear spurs and alternate depressions due to the erosion of the rather sandy materials. The clubhouse is on the south slope of the flat-topped ridge, and fine groves of pine are the appropriate product of the sandy soil.

The city of Amsterdam with its suburbs affords dense settlement for four miles along the north bank of the river, reaching up and over the steep valley walls to the north. These conditions have given us many instructive sections, and we have almost everywhere washed drift lying above till. We begin, however, with Port Jackson, that section of Amsterdam which is south of the Mohawk river. Here on either side of the South Chuctenunda creek are platforms consisting of lacustrine beds resting on till.

On the west side is Yankee hill, deeply cut for the West Shore Railway. Much slipping has since taken place, but earlier views showed a few feet of silts sharply capping an irregular top surface of till, at altitudes of 400 to 420 feet.

East of South Chuctenunda creek is a flat-topped ridge more than a mile long, with altitudes up to 440 feet or a little above. The top is of yellow silt on heavy stratified clay. The north half is nearly level but has some small shallow pits, not typical kettles, but sags with flat bottoms. The south half of the ridge seems morainic but with silts superimposed and the reliefs perhaps later accented by dissection. We seem to have a hilly moraine more or less fully occupying the preglacial triangular basin where the South Chuctenunda then joined the Mohawk. This was later masked as on Yankee hill by the washed drift.

South of the Dutch Church, where the road turns up the hill toward Minaville, a section shows 15 feet of fine black clay which is in part at least due to the working down of the Utica shales of the region. Here in the clay, striated fragments are fairly abundant. To the south and toward the top of the hill on the east of the road is a brickyard. The top of the pit is about 20 feet lower than the road, which is there at 400 feet. The section shows 30 feet of solid laminated clay, oxidized for 10 to 12 feet at the top, the rest black and of exceedingly fine texture. A good number of finely glaciated stones lie on the floor of the pit, including a number of small boulders. Here we have lake clays, into which icebergs dropped these interesting fragments.

Reviewing now the conditions on the north side of the river, Green Hill Cemetery and the district locally known as Cork hill belong to a platform of washed drift at 420 to 440 feet. The subsoils are variable with clay, sand and gravel, the east end or newer part of the gravels being of coarse material and always well drained. An opening on Cork hill showed well-stratified, coarse sand which screened out some gravel. A small district, thickly settled, north of the Kellogg dam is an extension of the cemetery area of washed drift.

In a ravine cutting the slope nearly a mile west of Church street and the cemetery, on the east side of the road, are 30 feet of typical till with striated boulders, and overlying are six to eight feet of sandy silts horizontally stratified. The altitude is 440 to 460 feet.

The great pit north of Guy Park avenue, opposite Caroline street, was open for many years. There are about 60 feet of exposure, the top of the section being at the 400-foot contour. The pit is 40 rods long, the basal parts of the section showing till with great numbers of well-striated boulders and the top consisting of about 10 feet of stratified, fine sands. Ground waters issue at the top of the till. Here the silts at the sides come down to the base of the hill, showing that at this point there has been no powerful erosion by Iroquois currents. This pit is described as it was in 1906. It has now been long

abandoned. The floor and sides are nearly covered with vegetation and on one part of the back slope we might call the trees a forest. Likewise many sections along the West Shore Railway and the Schenectady and Gloversville electric railway are now obscured.

Next to Caroline street is Evelyn avenue, running up the steep slope to the northwest. Exposures of 12 feet show tough blue till at the base overlaid by stratified materials, including some clay but chiefly yellow sand. At the top of the steep hill Evelyn avenue intersects Greenwood avenue. Above the latter for some distance the banks made by grading Evelyn avenue show the yellow sand.

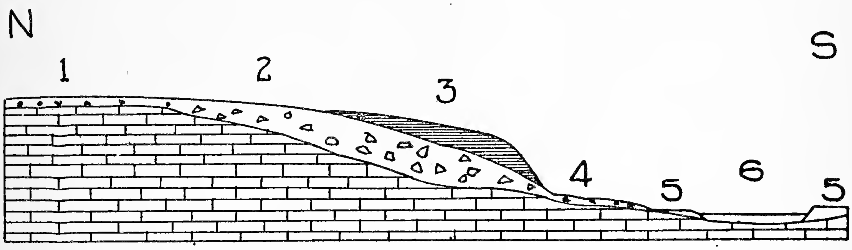


Figure 6 Generalized section at Amsterdam and other points along the Mohawk river looking east
1 Till veneer on the upland
2 Massive till on the valley side
3 Shoulder of water-laid drift
4 Eroded till washed boulders
5 Flood plain very narrow, absent in places
6 Mohawk river

West of the intersection just named at the head of a small ravine an extensive excavation shows 50 feet of gravel and sand. A few boulders appear near the top but in general there is an alternation of gravel and silts with 10 feet of sand at the bottom. A few rods away there is blue till on a level with the sand.

Farther west toward Fort Johnson sections are like that of the big pit opposite Caroline street, showing till at the base and washed materials above. Fairview and St Mary's cemeteries in this locality show interesting irregularities of deposit. In Fairview cemetery the superintendent informed the writer that the sand is in patches, sometimes with gravel in all the lower parts of the field, with clay in the upper part.

Similar conditions prevail in St Mary's cemetery, with mixtures of loam, sand and clay. If one burial lot is dry there is no certainty that the next one will also be dry. The clay subsoils predominate, and in both burial grounds springs and ground waters are quite too common. Conditions strongly suggest deposition on the borders of an ice

tongue. The altitudes are 420 to 440 feet. The contouring of the map is here very faulty, the flat shoulder appearing 100 feet too high.

Going north along the creek valley above Fort Johnson we have exposures varying from 50 to 125 feet above the Old Fort. At the lower levels are irregular beds of coarse sand and beds of sandy till. Farther up the valley but at a level with the last are horizontally bedded silts. Higher up is a crumbly clay, fine in texture and dark in color. Still farther up, at 440 feet, are loamy silts. Here also the contouring is at fault, as there is really a tabular surface at the altitude just named.

A highly interesting and instructive section is found in McFarlane Brothers' sand pit, west of Northampton road in Amsterdam. The section (figs. 7 and 47) shows from the base, blue sand, silt alternating with sand irregular in stratification, then sands and silts and at the top three to seven feet of laminated clays. The last look like a water-laid till, having plentiful stones and boulders, some of which are typically glaciated.

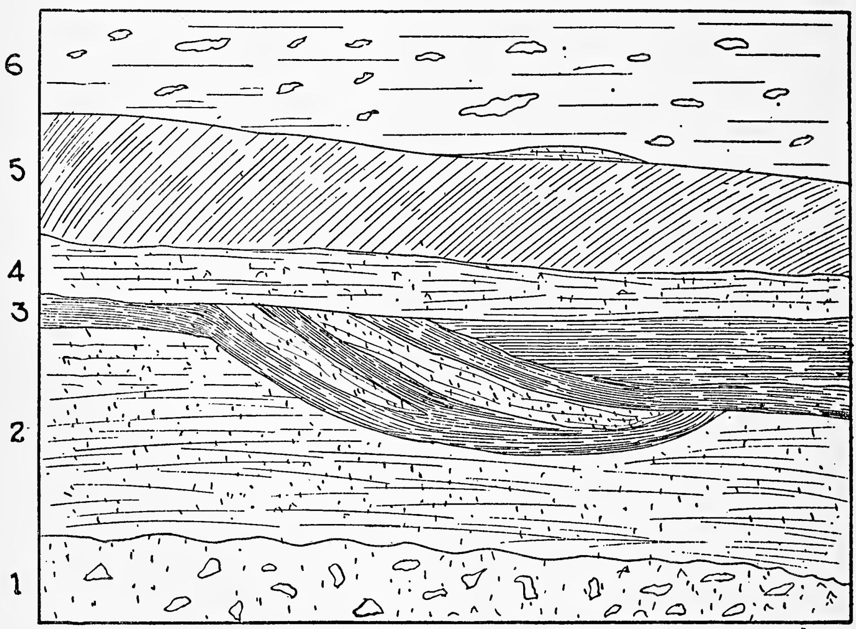


Figure 7 MacFarlaine Brothers' sand pit, Amsterdam. Read from bottom up.

6 Laminated till with ice-borne stones 3–7 feet
5 Silt, 3–5 feet
4 Sand, 1½ to 3 feet
3 Silt alternating with sand, 1–6 feet
2 Bluish sand 6 feet maximum
1 Talus

We seem to have here the combination of tumultuous and horizontal deposition which we might expect in a kame terrace, with berg deposits at the top. It will be remembered that a similar condition is found south of the river at Port Jackson.

Going east in Amsterdam, we find the same conditions as elsewhere. North of Main street, opposite Vrooman street, bed rock is covered with till, and going up the hill we find the rock covered with horizontal beds of sand and silt to a thickness of 35 feet. Here and eastward toward Cranesville is a steep bed rock valley side with a till mantle of variable thickness capped with washed drift.

One-half mile east of Cranesville the road begins to ascend Swartz hill. At about 400 feet A. T. are 30 feet of stony sand with many scratched fragments and little if any stratification. We may have here a washed deposit worked over by ice.

A bisected shoulder of washed drift stands north of Hoffman Ferry, between altitudes of 420 and 480. The easterly part is not brought out by the contours. No structure sections were seen but we doubtlessly have here deltas or sand plains at the mouth of the Chaugtanoonda and an unnamed stream one-half mile east of it. A mile east of Hoffman is the Waters station of the electric railway. Above this station along Verf creek, at 410 feet A. T., is a small washed shoulder representing the stage found in so many places westward.

A mile southeast of Rotterdam Junction, rising along a small unnamed stream, are several drift platforms of which the highest, at 400 to 420 feet is the broadest. The surface is uneven and very stony, which is not surprising when we note that nearly a thousand feet of steep slopes lie above it.

**Summary of Levels**

| | |
|---|---|
| Fonda wash plain | 440 to 460 feet |
| Near Randall | 400 to 440 feet |
| Schoharie wash plain | 440 to 460 feet |
| Tribes Hill | 440 to 460 feet |
| Antlers | 460 feet |
| Yankee Hill, Port Jackson | 400 to 420 feet |
| Port Jackson, South | 440 to 420 feet |
| Amsterdam, East of Church street | 420 to 440 feet |
| Amsterdam, west to Fort Johnson | 420 to 460 feet |
| Hoffman Ferry | 420 to 480 feet |
| Waters station | 410 to 480 feet |
| Near Rotterdam Junction | 400 to 420 feet |

Here are 12 localities of which ten fall within the range of altitude of 440 to 460 feet. When we consider the possible errors of the map, of the observer's determination by the barometer, and the vague

upper limits of a washed deposit, which are the rule rather than the exception, the accordance is here very striking. The determining cause of this accordance will be discussed in a later section.

We may here add a reference to a bench at Fort Plain, where Otsquago creek enters the Mohawk about seven miles west of our area. Here the altitude is 460 feet. The valley of the creek from Vanhornsville to Fort Plain has no high terraces or deltas of washed drift, but exhibits rather those forms of erosion and alluvial deposition which belong to a vigorous stream dissecting a heavy till and also cutting in places into the bed rock lying below.

Likewise the valley at Caroga creek is mainly cut in till, but has a small body of water-laid drift at Ephratah at about 740 feet. As above Fort Plain on the Otsquago, so above Palatine Church and along the Mohawk in that neighborhood, rather flat areas as seen on the map belong to the massive till that almost everywhere follows the inner trough of the Mohawk river.

## ICEBERGS

We have already noted the presence at Port Jackson and on the north side of Amsterdam of scratched stones in laminated clays, indicating the presence of ice on the border of lake waters. The subject should not be passed without reference to at least two other localities. About one and one-half miles west of Tribes Hill, by Danascara creek, we find a black, laminated clay with striated fragments. Apparently we have here the following succession: first a heavy till composed largely of the waste of the local black shale; then wash from the till land in dark clays with glaciated stones. If, as we suppose, the ice was near at the time of the deposition of these clays, a readvance would be quite possible, explaining the till over clay which we find in one or two sections along the river.

Three miles east of Port Jackson following a small creek southward and upward for one and one-half miles we find 70 feet of till of which the upper 15 to 20 feet are blue with scratched stones. It is very tough, has a pseudo-stratification and is apparently a berg till showing wavy horizontal lines in section but with no real sorting of materials. The altitude is between 600 and 700 feet.

The four places of berg deposition here recorded are within a space of eight miles in distance and within a range of 250 feet in altitude.

## IROQUOIS WATERS IN THE MOHAWK VALLEY

The body of sands and clays stretching from Schenectady eastward and southward was deposited as a delta in Lake Albany by the vast river which brought through the Mohawk valley the drainage of the Great lakes in the Iroquois stage. These floods, comparable to the Niagara, or St Lawrence of today, traversed the valley from Rome to Schenectady.

The Lake Albany waters stood where now, by reason of northward warping, we find the 360-foot contour. It will be useful to give the approximate altitudes of the surface of the Mohawk river from Rotterdam to Little Falls. The figures represent conditions prior to the construction of dams for the Barge Canal.

| | |
|---|---|
| One mile below Rotterdam Junction | 220 feet |
| Hoffman Ferry | 240 feet |
| Amsterdam | 260 feet |
| Tribes Hill | 280 feet |
| Fonda | between 280 and 300 feet |
| Canajoharie | between 280 and 300 feet |
| Fort Plain | between 280 and 300 feet |
| St Johnsville | 300 feet |
| Below the rapids at Little Falls | 320 feet |

The figures now given bring out facts about the Iroquois river that are often overlooked. Not taking account of the lowering of its bed by the postglacial Mohawk, which has been small in amount, its glacial predecessor was 140 feet deep at Rotterdam, 100 feet deep at Amsterdam, 80 feet deep at Tribes Hill, diminishing gradually to 60 feet at St Johnsville, and east of the fault at Little Falls the river was 40 feet in depth.

If the greatest of these depths seems excessive even for a river of the first order, we must observe that virtually Lake Albany extended a long and narrow arm up to Little Falls, and that this would have existed if no river had passed down the valley. The valley is also very narrow in some places for such a current, and the increase of velocity thus caused, combined with the presence of lake waters, explains for us the various deposits of coarse gravel which we find.

The river gorge between the Noses is scarcely more than a fourth of a mile wide at the river level. Passing the gorge, the Iroquois waters spread out over a width of a mile, and a little farther down to a mile and a half. Here was therefore a sudden diminution of velocity and the coarser waste was deposited over the wide surfaces which now flank the river.

An important deposit of such waste in the form of coarse and well-rounded gravel occurs at Yosts Station, stretching for three-fourths of a mile or more along the railway and northward toward the cliff. These gravels have been extensively employed by the railway. This deposit has been long closed to observation. The waters of the Barge Canal have so raised the water table of the valley bottom as to create a long pond in the excavations made by the New York Central Railway. The description herewith given is quoted from the author's earlier paper on the glacial formations of the valley ('98, p. 207):

It has been opened for nearly its entire length for the railway and to the depths of from five to 20 feet. The valley bottom abruptly widens from a quarter of a mile at the Noses to nearly three-quarters of a mile here, though the Calciferous (now Little Falls Dolomite) cliff still rises on the north. The railway runs between the gravel bed and the river, whose flood waters now never quite reach the track. Except at the west end, where it is a few feet higher, the gravel rises about eight feet above the present flood plain. The material is fine, very uniform, with a sandy matrix, and pebbles rarely exceeding an inch in diameter. The gravel is so clean to the top as to support only a spare growth of weeds. Along the north border the surface slopes gently toward the base of the cliff. Fresh exposures by the steam shovel show the same inclination of the strata. A long and very fine exposure near the middle of the mass shows the beds inclining down the river from 3 to 4 degrees, with elaborate displays of cross-bedding.

It is plain that as the great and pent-up stream emerged from the narrow channel above, it dropped its well-worn waste as a kind of apron in the broader waters below.

South of the river is Stone ridge, a feature which has given a name to one of the two small villages that lie in part upon it. The West Shore Railway is at the northern base and an abandoned river channel is on the south. Crossing this channel midway, a rude terrace on the south edge of the ridge showed, in what was then a cornfield, one-half and in places three-fourths of the surface covered with well-rounded pebbles and small cobblestones. A state pit at the east end of the ridge shows coarse gravel with tumultuous bedding. The flattish cobbles show by their position that the depositing currents came from the west.

The village of Fort Hunter is in part on the west end of a ridge extending eastward a half mile. It rises out of the flood plain and is cut at one point by the stream, where it rises 45 feet above low water. It probably has a till base, obscured by slip, and is topped by silts and coarse gravel. The ridge seems to be a bar built into the Iroquois waters at the mouth of the Schoharie creek.

The latter has a large basin in the high Catskills and has always carried much waste. In the late glacial and early postglacial times the stream has cut down the massive barriers of till between Esperance and Fort Hunter. This would account for the glaciated boulders which seem to have been washed out of the base of the Fort Hunter ridge.

One mile east of Pattersonville is a flattish ridge rising above the Mohawk flood plain and extending by Rotterdam Junction to the bridge of the Fitchburg Railway. The Rotterdam ridge drops by an escarpment of 20 feet to the Mohawk flood plains on the north. Streets running north from the main road at Rotterdam Junction end at the top of the bluff. East of the bridge the ridge, at a height of about 60 feet above the river, continues eastward. It is south of the New York Central Railway and broadens as we pass into the Schenectady quadrangle toward the village of Scotia. The steep bluff cut by the Mohawk river where it leaves the quadrangle shows horizontal strata, in prominent relief, because some layers have been indurated by later infiltrations of cementing material. As described by Professor Stoller, we have here gravels deposited in Lake Albany by Iroquois floods, where the lake waters occupied the east end of the Mohawk trench.

The ridge is of silts, sands and coarse and well-rounded gravel, the latter predominating more to the west, as would be expected, the finer material being floated a little farther toward the great body of standing water. West of Scotia cross-bedding is seen with prevailing dips eastward.

An example of the coarse deposits of the Iroquois stage is found in a large gravel pit where the Mohawk turnpike descends from the Iroquois gravels to the flood plain on the north side of the river, a half mile, as seen on the map, north of the letter "J" of Rotterdam Junction. The pit is 300 feet long, and shows very coarse gravel, of but partly rounded fragments. It is full of cobblestones and of boulders up to a foot in size. There is much calcareous incrustation of the stones but no compacted conglomerate was seen. Many cobbles of black shale are now splitting with brief exposure. The only section of unslipped material showed pure gravel with no sand matrix (fig. 53). There are many limestone fragments. Thus the shales, limestones and calcareous incrustations point to the bed rock material of the valley and lime-charged waters moving down the lacustrine Mohawk in Iroquois times.

The ridge is constructional in form with rounded surfaces and no terracing or cutting comparable to the work now in progress on

the south by the Mohawk river. This is the condition to be expected when we remember that the Iroquois floods were here depositing their coarser burden in waters more than 100 feet deep. This preservation of the constructional forms, with other evidence to be cited, gives confidence to the view that Lake Albany survived and retarded powerful erosion of the lower valley, until the St Lawrence valley opened to Iroquois waters and left the Mohawk valley to local conditions.

It will be observed by the map that there is a small extension of Lake Albany sediments into the Amsterdam quadrangle, along the course of Norman kill. Here they attain an altitude of 360 feet as near Schenectady.

Very little constructional or destructional terracing at Lake Albany levels is to be found along the river in the two quadrangles concerned. Traces of deltoid shelves are to be found at two or three points, as near Rotterdam Junction above Pattersonville and west of Tribes Hill. The Pattersonville shelf is southward from the village at 340 to 360 feet. Coarser material with a rough surface runs up to an altitude of about 400 feet. We seem to have here a deposit of wash from the massive till of the great slope to the south, as it came to rest in Lake Albany waters. In a large pit opened by the State we find fine foreset sands at the outer or northern end of the deposit, with topset beds of gravelly sands farther back.

Two miles southward of Pattersonville, opposite Rotterdam Junction, a valley is cut in the escarpment, which is inadequately shown on the topographic map. Here we have mapped an Iroquois delta which is similar in appearance to that of Pattersonville. Small deposits of like character and suitable altitude appear on the north side of the Mohawk, down the valley from Hoffman Ferry.

It is very evident, however, that Mohawk valley sides were invaded before the major waters disappeared. The north valley wall has been undercut much of the way from Fonda to the east border of our district. It is this which has swept away the silts of the lower slopes and laid bare the till at so many points, as at Amsterdam. If the Lake Albany conditions outlasted Iroquois currents, we have still to remember that constant soakage and slumping at and below the 360-foot level would promote removal even by the gentle currents that prevailed in this deep lower course of the Iroquois stream.

The thick shoulders of drift that rose out of this lacustrine river gave conditions favorable for landslips. One mile east of Fonda on the north shore is a series of hillocks north of the turnpike, which

at first sight looks like kames. They are, however, without much doubt due to landslips. They are backed by a steep slope of 35 to 45 degrees, which could not have been constructional and could not have been eroded if the hillocks were kames present since the glacial occupation of the valley. One of the hills is long and parallel to the escarpment, as if once a piece of it. An opening shows a mixture of clay, loam and stones, like the stony wash of the slope above it, but with no stratification. There is hummocky gravel also on the road on the border of the flood plain. This may belong to the slipped materials. We can account for its preservation when we remember that the lacustrine condition softened the vigor of the Iroquois flow (see diagram, fig. 8 and photograph, fig. 58).

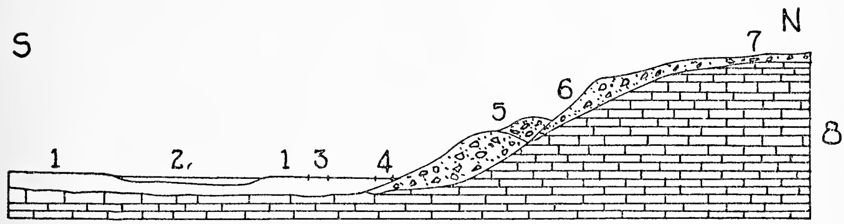


Figure 8 Section showing relations of landslip. Topography two miles east of Fonda. Looking west

1 Flood plain
2 Mohawk river
3 New York Central Railway
4 Highway
5 Landslip
6 Escarpment
7 Veneer of till
8 Bed rock

West of Port Jackson and of Yankee hill is a belt of hummocky ground under steep bluffs. We have here the same conditions as near Fonda. It is recognized that care must sometimes be taken to discriminate between morainic and landslip forms (Johnson, D. W., '17, p. 549).

In several sections of the valley we find abandoned channels of late Iroquois or early Mohawk age, and there are several belts of water-swept till. These are strips of valley bottom which must have been covered with Iroquois sediments that were gradually stripped off as the deeper waters subsided and removal agencies became effective. A very flat ridge of such till extends more than a mile east of Fultonville, with a disused channel between it and the West Shore Railway. Another example is found in the old valley floor running through the city of Amsterdam on the north bank of the

river. Another belt is below Hoffman Ferry and a fourth is on the north side of the New York Central Railway a short distance from the eastern border of the Amsterdam quadrangle.

East of this till is a small water-swept area of loamy clay, which is so mapped by Professor Stoller, as it passes into the Schenectady quadrangle. We are here in entire agreement with Professor Stoller, but have used the symbol for an abandoned channel, as consistent with the plan of mapping adopted in this report.

North of this washed belt at the very edge of the Amsterdam quadrangle is a sand and gravel terrace, of peculiar interest (figs. 55 and 56). It is a remnant of the Iroquois flood deposits, cut away between it and the railway. Its surface and its beds of sand and fine gravel dip toward the hill base on the north. They are well exposed in the sand pit of N. Haverly. It is still possible to see a remnant of these sands extending westward over the till, not having at that point been completely swept away (fig. 57). The fineness of the material is appropriate to its position on the northern and outer edge of the great ridge of Iroquois flood materials.

Although it is not in our district, we may properly here refer to a ridge of coarse gravel of the Iroquois stage lying on the north side of the New York Central Railway for about two miles between East creek and St Johnsville. It was no doubt a flood deposit from East creek and shows the same sort of coarse gravels and cementation which occur along the river at Rotterdam Junction and extend toward the city of Schenectady.

## THE PROBLEM OF GLACIAL RECESSION AND HIGH-LEVEL WATERS IN THE MOHAWK VALLEY

It has been a prevalent hypothesis that glacial currents entering and filling the Mohawk valley both from the east and the west disappeared by the recession of their fronts, leaving lake waters of varying extent and depth confined between them and overflowing across available high cols or between glacial tongues and the valley sides, the surfaces of the lakes being lowered as the ice waned and uncovered lower outlets.

Study of the lower Mohawk region, pursued at intervals for many years, has caused the present observer gravely to doubt the reality of the conditions outlined above, and for several reasons. These may first be stated briefly and in general terms, and then amplified and illustrated by local details.

1 There is in the field of the Mohawk glacier a remarkable absence of recessional moraines. The only possible exception in our

region is in the kames of Glenville and a few patches of morainic till on the very eastern edge of our area. The hill region south of the Mohawk, in its smooth and long-drawn drumloid curves, is free from moraines save in the trivial accumulations near Carytown and Oak Ridge. Brief reconnoisances as well as observation of the maps show the same conditions, as we believe, to prevail in the Lassellsville, Canajoharie, Richfield Springs and Winfield quadrangles, that is, in those portions of these quadrangles which were dominated by the Mohawk glacial lobe.

2 We do not find on the higher slopes of the Mohawk trench evidence of water levels, in the form either of wave-cut hillsides or delta terraces and bars due to accumulation. It would seem that lands freshly rid of ice would send much waste down the slopes, which would be arrested at the edge of a body of water. If it be said that only small streams, excepting the Schoharie creek, flow from the southern slopes of the Mohawk, east of the Winfield quadrangle, we may cite the case of the deltas of Coy glen and others on the slopes of the Finger lake valleys, where small streams have made notable accumulations. Small interlacustrine ridges furnished the drainage for these glacial waters. It is also well assured that in a lake of great length, and from a dozen to thirty or forty miles in width, there would be a fetch of waves and a cutting action that would be clearly recorded.

3 Water levels do appear along the Sacandaga river and on the East and West Canada creeks. We believe that local conditions in connection with melting ice borders explain many and possibly all of these conditions. We are confident that this is true in the case of the water-laid forms of the Sacandaga valley and the reasons for this conviction will be later stated. Certain high-level deposits in the valley of East creek in the Little Falls quadrangle have been ascribed to shore lines of large lakes in the Mohawk region. We here cite the conclusions of Professor Cushing in his report on the Little Falls quadrangle ('05, p. 75, 76). Referring to sands and laminated clays, we find this statement concerning "flat-topped benches with steep sloping fronts." "They lie at all sorts of levels from 800 up to 1500 feet. Their form is often that of delta deposits, but, if such, they represent merely very local and rather rapidly shifting water levels." Professor Cushing then speaks of a shrinking Mohawk glacier with local lakes on the edge, receiving deposits from East Canada and Spruce creeks.

4 Some of the cols and escarpments over which or above which high-level glacial waters must have escaped, if they existed, do not seem, after careful observation, to show sufficient evidence of their

passage. As we confine ourselves so far as possible to our district and its immediate borders, we refer here especially to the Delanson col and the Rotterdam and Helderberg scarps as being natural routes of outlet for elevated waters.

5 Our conclusion therefore is that in the water-laid drift at and below 460 feet we have the chief evidence of extended waters of even moderate elevation. This does not exclude the passage of drainage across or down the Mohawk valley on stagnant ice.

The accordance of levels between 440 and 460 feet, with moderate departures above and below, is too pronounced for us to avoid the conclusion that a long and straggling lake occupied the greater part of the inner trough for a considerable period. This does not exclude the presence of local waters beside a stagnant ice tongue, merging possibly into a continuous lake from Little Falls eastward as the ice melted out. Moderate differences of altitudes suggest some localization of ice border lakes, and we may now recall the fact that we have found berg deposits as far up the valley as Amsterdam, also some evidence that there were ice-contact conditions on the south edge of the Fonda plain. We may add possible ice-contact slopes preserved on the river edge of the high-level shoulder at Tribes Hill. The washing of the valley side drift in Iroquois floods may have destroyed ice-contact slopes at many points.

6 After the waters of the Ontario and more westerly ice lobes turned from the Chicago outlet and flowed eastward, they must somehow have found exit by the Mohawk valley. How did they go, if not through a lake or a series of lakes of lower and lower levels? It has long been our conviction that glacialists in general have underrated the possibilities of drainage across great bodies of stagnant ice, which, as higher lands are exposed, may be so covered with drift as to insure preservation for thousands of years. The Mohawk valley was so situated, athwart the main southwesterly drive of the great ice sheet, as to favor stagnation and prolonged survival.

It was not until this report was taking manuscript form that the writer found and read a paper by Cook ('24) on "The Disappearance of the Last Glacial Ice Sheet from Eastern New York." Here views expressed regarding receding and opposing ice fronts and regarding the presence of important bodies of stagnant ice confirmed the convictions which field study of the region long ago compelled the writer to adopt. Further references to this important paper will be in order as we proceed.

We begin our review of the evidence, in a more detailed and local manner, by referring to certain water-laid bodies of drift, which we

have already found upon the Broadalbin quadrangle, and have described in the sections on the Glacial Lake Sacandaga and on Sand Plains. Several of these have been referred by Professor H. L. Fairchild to his Lake Schoharie and Lake Amsterdam and have been so mapped by him ('12, p. 35, 36 and plate 8). There is no room to doubt that the water-laid drift of the Broadalbin quadrangle is fully to be accounted for by the local conditions which we have already described. The Edinburg sand plain is mapped by Fairchild as belonging to Schoharie lake. The deposit was made, however, on the edge of a local ice tongue. Its maximum altitude is about 1060 feet, while the Delanson col is at 840 feet. If we allow 75 feet for differential uplift at the north as between the two points, we still have a discrepancy of 145 feet. This in our judgment would in any case have been too great a difference for correlation. We could not concur in Fairchild's reference to the Knox-Delanson outflow of water levels on several Mohawk tributaries, varying from 820 to 1200 feet ('12, p. 28, 29). Professor Fairchild rules out the Knox divide at 1160 feet as having carried no water. A re-examination of the Broadalbin quadrangle during the current season confirms the conclusion already reached. The Edinburg sand plain, although composed of fine and silty sand, presents on its eastern and southern fronts bold and strong slopes which could not have been made in a body of open water. As we have seen, the Edinburg sand plain is similar to those at Benedict and Hagadorns Mills. Cook makes the same interpretation ('24, p. 169) referring to "sand plains built over against its thin edge (that of the ice) by the Sacandaga river near Northampton." We suppose that Cook means plains built on *tributaries* of the Sacandaga. In any case their variant altitudes do not admit of their marking a single lake level.

The map to which we have referred distinguishes several areas as belonging to Fairchild's Lake Amsterdam. At the opening of Gifford valley, west of Northville, most of the area thus marked is kame moraine and till representing the Sacandaga local ice front from which the delta of glacial Lake Sacandaga springs. The contrast between the moraine and the delta terrace is sharp, the latter lying against the former (fig. 40). Up the river the valley is so blocked with massive moraine for a mile above the delta that the main highway to Wells and northward passes at some distance from the river and goes up the valley of East Stony creek to Hope Valley. There the road crosses a flat saddle of washed drift and returns to the Sacandaga two miles above the delta. This saddle at 900 feet is not genetically related to the head of the Sacandaga delta at 780 feet. The

high terrace north of Northville village is a local sand plain. The terrace on which Northville stands is part of the local delta of local Lake Sacandaga, as is also the plain on which Sacandaga Park stands. The entire deposit from the moraine above noted southward to a point east of Cranberry creek belongs without question to the delta in the glacial Lake Sacandaga. Where the Fairchild map passes from a supposed deposit of Amsterdam waters to a local Sacandaga lake delta, there is perfect continuity of level and of materials. It is beyond question all of one piece.

The long, flat hilltop between the two limbs of the Sacandaga river, colored as of Amsterdam lake, we interpret not as a water plain, but as a till veneer whose surface is determined by the great mass of horizontally bedded Little Falls dolomite, upon which it rests. We have a rather even hillcrest, slightly rolling in places, showing no sign of wash, deposition or cutting and everywhere showing the presence of till.

Professor Fairchild carries a lake tributary to Mohawk waters through the Sacandaga valley, bearing, for a period of ice-blockade in the Hudson valley, much Adirondack drainage ('12, p. 35). We have only to say that we have not found evidence of the presence of such waters in our field of study. On conditions to the eastward, we cite Professor W. J. Miller in his study of the Luzerne region ('21, p. 53): "It is with some hesitation that the writer expresses his doubt concerning the existence of such high-level waters in the quadrangle, but he certainly was unable to locate anything like persistent, well-defined delta lake deposits at any such level through the Hudson valley."

The Delanson col, at 840 feet, between a small branch of Schoharie creek and Normanskill, is two miles west of the Delanson station and one mile south of the southern boundary of the Amsterdam quadrangle. It has been interpreted as the control of a Lake Schoharie extending probably from Utica to Johnstown. If this col carried any considerable stream it would have passed into the Hudson lowland (on the theory of a progressive recession of the icefront) first through Boxen kill and later by way of Normanskill.

The surface of the Delanson pass west of the crossroad leading south is apparently of till with numerous flat and angular stones such as are seen commonly in the till of this region of sandstone. They were seen in the col and in stone walls. The surface of the col slopes gently from the north and from the south to the railway track. There is at the base of the main valley slopes no sign of a

cut stream bank. East of the crossroad, in the direction of Delanson, the ground is flat and a little boggy but there are no cut banks.

The valley west of the col is broadly V-shaped but narrow, barely carrying, where the lake would have been 40 feet deep, the small stream and the railway. There is no sign of beach cutting between Delanson and Esperance, although west winds would here have had a fetch of four to six miles. Recalling other and modern levels and the cut beaches on the Finger lakes, we should expect some record here. We cite even the Madison reservoir on a headwater of the Chenango river, a pond two miles long and a quarter of a mile wide, on whose borders pronounced work has been done since the waters were dammed less than 100 years ago.

If much water came over the Delanson col it would have passed into the Hudson valley trough first by the valley of Boxen kill, which diverges from the Normanskill valley over a low pass about one mile south of the village of Duanesburg on the boundary between the Amsterdam and Berne quadrangles. For about one and one-half miles to the southeast there has been no stream cutting. The valley slopes are scarcely modified mantles of ground moraine.

For about four miles below the Schenectady-Albany county line the Boxen kill runs through a deep gorge, cut in the bottom of a mature valley. The rock is shale, with sandy layers but easily eroded. The stream where seen at several points is cutting vigorously on a rock floor a bed from 60 to 80 feet wide. The kill is quite adequate to the making of this gorge in postglacial time. It has a fall of 400 feet in a distance of five miles. Several strong tributaries feed the stream from the high slopes on the west. These torrential branches have in several cases cut deep gorges in accordance with the main trough.

Along the Normanskill between Delanson and Duanesburg are some swampy flats which may represent a foot-lake deposit in front of a Normanskill ice tongue. There are no terraces or suggestions of alluvium other than a few patches of recent flood plain. The Normanskill depression is spacious and impressive as seen from the hills south of it and must have held at some stage a melting tongue of decadent ice protruding from the Hudson valley.

If we postulate a cover of stagnant ice in the Delanson col and in the valleys of Normanskill and Boxen kill we can imagine the passage of waters from an ice-filled Mohawk valley. Observation of the ice-free surfaces of today does not suggest that we have here abandoned stream channels, recording late glacial activity.

In the light of the facts as we have been able to observe them and as they have been outlined above, we retain the name "Lake Schoharie," in the local sense, as originally employed by the writer ('08, p. 29, 30). We have here evidence of a well-defined body of water of which the conditioning cause, the deposits and the mode of disappearance are assured.

It is recognized by all that a westward or Chicago outlet of glacial waters was followed by such lowering of the ice barriers in the Mohawk region as to reverse the flow from western and central New York and send it eastward. The critical altitudes for this change were a little below 900 feet. It is not within the sphere of this report to discuss the flow and subsidence of the waters in Central New York from the 900-foot horizon down to the Iroquois level. We simply recall the rock channels, fossil waterfalls and plunge pools near Syracuse, the scourways on the northern slopes of the plateau in central New York, the high-level terraces between Rome and Little Falls and the down-cutting of the ancient col at Little Falls.

The waters that were active in these works of erosion and deposition found their escape through the Mohawk valley from Lake Warren time to the Lake Iroquois stage. Our present query is simply this: How did these waters, flowing for a long period of time, cross for a distance of about 26 miles the region which has been described in this report?

We are not here considering waters of higher level in central New York which may have escaped across high cols at the head of the Susquehanna system, as these do not relate themselves to our present study. For the same reason we do not enter into the question of drainage from the Black river valley and the Adirondacks across the Mohawk ice or through lake waters in the Mohawk valley.

Serious doubt as to the reality of great water bodies in the Mohawk region suggests inquiry as to how these waters reached the Hudson and the sea. With the down-cutting of the Little Falls barrier and the release of the waters held to the west of it, there ensued erosion and removal of great bodies of waste that had come from the west into the spacious valley that led down to Little Falls. In addition the Chittenango, Oneida, Oriskany, Sauquoit, West Canada and other streams unloaded their waste from south and north in the same spacious valley. We should question Fairchild's suggestion that this valley may have been completely filled with washed drift but we are prepared to believe that there were

large accumulations stored on the floor and sides of this deep and wide trough.

This plentiful waste would seem competent to mask a body of stagnant ice along the Mohawk and long preserve it from melting. We may perhaps safely visualize the copious but changing and braided streams of glacial water that marked its surface.

In discussing the thickness of the Mohawk ice we have already cited Dr I. H. Ogilvie's paper on the Paradox Lake quadrangle, as postulating much stagnant ice in the Adirondack valleys. In her earlier essay, also cited, on Glacial Phenomena in the Adirondacks, she concludes (p. 400) "that the ice entered the region from the northeast, flowing on in that direction toward the southwest where open valleys afforded opportunity, becoming stagnant in narrow valleys," and finally at the time of its greatest advance burying the region entirely, an "upper southwestward moving current, passing over the stagnant valley masses below." Doctor Ogilvie also states that there was little glacial work in the deeper valleys of the central mountain area but that the summits were markedly smoothed.

The Mohawk valley is a capacious trench and might therefore be expected to be unfavorable to conditions of stagnation. Other conditions, however, distinctly favor stagnation. The Mohawk valley stands athwart the main southerly trends of the entire body of Laurentian ice. From New England to Wisconsin there is no comparable assemblage of relief conditions in reference to the main trend of the ice movement.

We are compelled to accept a late and strong westward movement in the Mohawk Valley. We have given reasons for believing, however, that at the time the Adirondacks were not an island in the ice, but were largely covered with a thick mass of ice mostly stagnant. If the same conditions of stagnation obtained on the northern slopes of the Catskill-Allegheny plateau from the Berne quadrangle westward, then we have the Mohawk lobe, vigorous as it was, gradually giving up its motion in the presence of retarding frictional conditions. What were these conditions? (1) The long push through the rugged Champlain-Middle Hudson trough; (2) the swing from a southward to a westward motion of the ice; (3) the uphill push from the Hudson valley to Cedarville; (4) this push was impeded by the contacts of the active ice with great fields of stagnant ice both in the southern Adirondacks and on the northern parts of the southern plateau; (5) underneath were the rugged portals of the Mohawk near Schenectady, the angular turns of

the inner trough of the Mohawk west of Schenectady, the spurs and escarpments of the Hoffman and Noses faults and the deep and preglacially matured Schoharie valley in a north and south alignment, which must in some measure have tended to retard the westward thrust of the ice.

We here cite an example in the Chenango headwater valleys, which tends to prove that ice blocks may survive under a heavy cover of land waste for a very long period. Summit Water, two miles north of Hamilton, is a glacial lake which furnishes the municipal water supply. It is about 90 feet deep and occupies the entire valley floor between two glacial terraces. Here was the outlet from the Oriskany and Oneida valleys during the period while the ice fronts in those valleys were building the enormous masses of moraine which block both valleys for miles. The delta in front of the Oriskany Falls kames at Solsville is now being opened by the Madison Sand and Gravel Corporation. Its deposition calls for a vast lapse of time. All the drainage had to escape over the present position of Summit water. The present basin would have been aggraded innumerable times by the escaping glacial waters, if it had been given repeated existence. We are forced to the conclusion that ice, deeply sealed in, maintained the level, and then sank away after the waters from those north sloping valleys had ceased to flow over the water parting on the south.

The possibility of large areas of stagnant ice, persisting for considerable periods, is recognized by Professor H. L. Fairchild for the Mohawk valley, although he conceives of the later disappearance of the ice in that valley by receding fronts on the east and west. He postulates the clearing of the Adirondacks and the Catskill-Helderberg plateau and a "strait or neck of ice in the Mohawk valley connecting the Ontarian and Hudsonian ice lobes" ('12, p. 6, et. seq.). Fairchild thinks that glacial waters gathering about the Adirondacks must have escaped across this strait of ice which he later (p. 19) refers to as "the belt of stagnant ice which lay in the Utica-Little Falls sections of the valley." The col north of Otsego lake is considered (p. 23) as a probable escape for Adirondack waters across "the strait of ice which filled the valley on the north." The ice if thus stagnant and carrying northern waters to the Susquehanna valley, would have been at least 1000 feet thick over the present channel of the Mohawk river.

As has been already suggested, the existence of stagnation of wide extent and long duration has been supported by J. H. Cook ('24), who concludes, in connection with studies in the

Albany and Berne quadrangles, that "the clean, unmodified surface of the fluted and drumlinized area of the Helderberg plateau negatived the assumption that glacial lakes had ever existed on its northern slopes, held in by an ice barrier at the north, or that ponded waters from the Schoharie valley had ever found outlet across these slopes as such an ice front withdrew. This observer then develops his argument that wide areas of ice pushed beyond the mountain barriers south of the St Lawrence river became stagnant soon after the height of glaciation and so remained. For the considerations which support this view we must in the main refer the reader to the paper cited.

We could not go with Cook in the degree to which he would emphasize a condition of stagnation in long north and south valleys like the Hudson or the Chenango, but he rightly puts in contrast the "readable topography" of some western ice lobes with those of eastern New York. Cook, like Fairchild, seems to accept the possibility of Adirondack waters passing across the ice into some Susquehanna outflow. The writer has already sufficiently emphasized the absence of recessional accumulations in his field of study. We are inclined with Cook to view this condition as an evidence of widespread stagnation in the Mohawk valley.

The absence of any evidence of recessional fronts is in our view matched by the paucity of evidence which might show high-level waters in the valley. The conditions as regards water levels have been somewhat fully set forth and need not be here repeated. We should not leave Cook's paper without calling the reader's attention to his citations of Fuller and Clapp dealing with glacial Lake Neponset and the Charles river basin. On the latter Clapp has the following significant passage, "The decay of the ice *in situ* for many miles back from the ice front—the decaying glacier consisting of a mass of stagnant ice, overlain and buried by sheets of water and by extensive deposits of sand and gravel." Both the Fuller and the Clapp papers are in the Journal of Geology, volume 12.

Returning briefly to the question to which this section is devoted, ample waters flowing for a long period of time as measured by erosive work accomplished in central New York, passed across our two southern quadrangles. If any of these waters, or some small earlier flows, went across an ice-clogged col at Delanson, all the rest must have gone out past the Rotterdam slopes at higher or lower levels, either through lake waters or over drift-covered and stagnant ice.

It does not seem to the writer that the evidence is yet available for a full or final discussion of the problem as we have stated it. In our view the necessary data are likely to be at hand, when a detailed survey and mapping have been accomplished for the quadrangles along and near the Mohawk river from the lower valley westward to Utica, Rome and Oneida.

The water-laid waste of the Mohawk stands conspicuously around 600 feet above Little Falls and about 460 feet below that point, with lower levels toward Schenectady determined by the Iroquois flow, as free passage was opened to the Hudson valley.

Assuming the long stagnation of Mohawk ice as possible, as its surface in the lower valley gradually suffered ablation below 500 feet, the débris of the higher slopes readily washed down and formed the deltoid borders and aggraded shoulders which lie between 400 and 500 feet and tend to concentrate in the middle of that interval.

Further melting both in the Mohawk and Hudson valleys allowed the waters to sink to the Lake Albany level from Little Falls eastward. In this long episode of what we may call flowing lake waters, much washed material was trimmed from the sides of the Mohawk trough. As the waters fell in the Hudson valley much more waste was excavated from the Mohawk floor and borne away. We thus arrive through the moderate changes of postglacial time to the conditions which now appear.

## POSTGLACIAL CHANGES

Whenever a glacial cover is removed in a particular locality, weathering, rain wash and stream action come into play and produce large results in a short time. Without a cover of vegetation, and showing in many places steep constructional slopes, the land surface changes rapidly. The principal areas of ice, or lesser remnants, may be still in existence elsewhere and we can hardly call their modifications postglacial. Yet they contribute to and merge into conditions which have continued through postglacial time to the present.

### Postglacial Changes Apart from Human Agency

**The work of streams.** The major streams of our district are the Mohawk river, the Schoharie creek and the Sacandaga river. Our section of the Mohawk valley lacks some of the typical features of normal river activity. It shows few meanders and no typically developed series of such curves. It is thus in contrast with the section of the valley between Little Falls and Rome. There we find wide floods and pronounced meanders due to the sill of hard

rocks at Little Falls, which creates a local base level. In like manner the ordinary alluvial terrace is hardly found in the lower section of the Mohawk valley from Little Falls to Schenectady. Islands in the Mohawk river, about two dozen in number, find place on the map between Tribes Hill and Hoffman Ferry, a distance of about 12 miles. These are mainly built of waste brought in plentifully by the Schoharie creek, which has done a large amount of erosion and transporting work in its long course among the highlands of eastern New York.

It should here be observed that we have mapped all the flood plains and islands of the Mohawk as they were before the construction of the Barge canal raised the water levels.

The Schoharie creek, within our district, that is, in the Fonda quadrangle, stands in high contrast with the Mohawk in the presence of a highly developed series of meanders, terraces and abandoned oxbow channels. The meanders are incised upon a thick and rather irregular filling of glacial waste, to which reference has already been made. The creek and its bordering forms, of rock, alluvium, glacial till and benched upper slopes, would, if properly modeled, be a useful adjunct to geographic instruction in the schoolroom and the physiographic laboratory. We are referring to the 15 miles of its lower course between Esperance and Fort Hunter.

It is fully evident from the map that the valley was at several points solidly filled with till. Cut saddles of this till may have crossed the valley where it enters the Mohawk trench, a mile south of Fort Hunter; also at Mill Point, and at the power house two miles above Mill Point. There were probably several small lakes held between these till barriers, until they were breached by the action of the stream in grading its course.

This lower section is marked by highly developed flood plains, terraces and abandoned channels, framed in till slopes, which are at many points exposed in stream-cut cliffs. The upper section, for about six miles, is a rather narrow gorge, in which the flood plain is not present or is trivial in extent.

This narrow valley, with no continuous flood plains, and in parts with none at all, has had a singular negative effect as regards human occupation. The stream passes from the long Burtonsville gorge and then begins to swing from one side to the other under the steep cliffs which it has formed. Hence no highways and no railway have found their way here, although these works of man are found in the broad valley above. The roads near the stream are short and broken and then they climb out upon the hills. At several points roads lead down to the flood plains and end at a farmhouse.

The Sacandaga river, being reversed in flow at Northampton, found its outlet at Conklingville over a col so high as to give the river a sluggish flow in the Broadalbin quadrangle. Hence the mountain land waste has tended to accumulate along the stream from Northville to Conklingville. The flood plains are wide and there are pronounced meanders above Batchellerville, and islands above Osborn Bridge. We have already noted the broad fragment of a river terrace northward of Osborn Bridge.

Several postglacial gorges have been formed by some of the minor streams. The Danascara creek between Fonda and Tribes Hill undoubtedly entered the Mohawk near Tribes Hill or opposite Fort Hunter. Its old course being filled with drift the stream has turned south, cutting a fine gorge in the bed rock of black shale, and enters the Mohawk below the De Graff mansion, which is on its west bank.

A similar condition exists at Port Jackson. The South Chuctenunda creek entered the Mohawk farther east, until the masses of drift along the Mohawk filled the lower end of the valley of the tributary. Then the stream found a lower level a little to the west, where it also has made a small gorge in the black shale.

We have referred to an unnamed stream rising west of Scotch Bush and entering the Mohawk three miles east of Port Jackson, as showing massive till and having above its gorge deposits of berg clay. The gorge itself as a piece of stream work is but poorly represented on the map. It is V-shaped and averages 100 feet in depth, with segments of meander curves on its slopes and one landslip hill of considerable size, consisting of material which has fallen from the east side. Large till accumulations 100 feet or more deep occur here. Doubtlessly the period of accumulation was vastly longer than even a small stream has required to sink a gorge and reveal the nature of the material.

A similar condition appears in the Cranesville valley east of Amsterdam, where a gorge more than 150 feet deep cuts through the drift filling on the western side of the preglacial valley, leaving a massive drift shoulder on the east side.

Abandoned stream courses are found south of Randall and Stone Ridge, east of Fultonville, and around "Tayberg" in the village of Fonda; also below Hoffman Ferry on the north side of the Mohawk river. Several short sections of old stream ways occur in the Schoharie valley.

There are but few places in our region where a torrential stream with steep gradient opens abruptly into a mature valley. Hence we find few alluvial cones of such size as to require a place on the map.

An example of such a form occurs north of Yosts Station where a narrow gorge in the Nose uplift opens upon the Mohawk plain. Other examples are found at the foot of the steep slopes south of the Mohawk, as at Hoffman Ferry, Pattersonville, Rotterdam Junction and eastward. Considerable slopes of talus are found along the Mohawk river at the base of the cliffs of the Noses.

**Lake filling and accumulations in marshes.** In a settled region it is not possible to measure deposits of the kind here named, as resulting from natural processes alone. Man has had a large part in such results, mainly through the removal of forests and by tillage.

In the Adirondack section are many swamps, due to glacial clogging of a once matured drainage. Here are unknown thicknesses of vegetable matter and fine land wash. No doubt all the lakes have been restricted by this means. This is quite evident in marshes adjoining East and West Caroga lake, Peck lake, Chase lake and many natural ponds.

Marsh areas are numerous in the belt of the interlobate moraine both east and west of Gloversville. Small marshes are quite numerous even among the drumloid hills in the southern parts of the Fonda and Amsterdam quadrangles.

By far the greatest area of marsh land is of course in the Great Vly south of the Sacandaga river in the Broadalbin quadrangle. Here it is particularly difficult, or rather impossible, to determine the measure of change. It is obvious that fields shown on the map as marsh are under tillage. The rapid erosion and filling of late glacial times contributed its quota. Then came thousands of years of vegetable growth and decay, followed by the short period of man's work. The filling of these low grounds is a composite of these several agencies and periods of time.

## GEOGRAPHIC CONDITIONS IN THE LOWER MOHAWK VALLEY

### Introductory Statement

We have purposely used the words "geographic conditions" rather than the term "geography." Geography, without qualification, would require a treatment much more symmetrical and detailed than the purpose of this report and the space available would permit. It is plain that statistical treatment, particularly of the subjects of population and agriculture would be impossible or at least impracticable, because the quadrangles of the Geological Survey are laid out with reference to lines of latitude and longitude and pay no heed to the boundaries of counties, townships or municipalities.

We propose to show in outline how man has entered this field and used it as his home and sphere of activity—a sketch rather than a completed portrayal. We find here a series of human adaptations to physical conditions. There has been a progress of settlement, a growth of towns, a development of agriculture and an unfolding of manufacturing industries. All of these, although to a lesser degree true of the last, have been rather intimately related to the rocks, the relief, the drainage, the drift deposits and the climate of the region. Physical and historical, populational and industrial, rural and civic geography, all find place here, although it is neither necessary nor possible to place them in close compartments or make a strict analysis. Here is a physical area having a fair degree of coherence if not of unity. Our query is: What has man done with it and to what degree may he have the intellectual satisfaction of interpreting what he does, by what nature has done in the long durations that preceded his coming and his toil?

The literature that unfolds these human doings is fragmentary but abundant. It is found in many volumes of Indian lore, in innumerable essays and volumes of history, in poetic, reminiscent and fictional writing, in state documents, the statistics of government departments and the proceedings of historical and other societies. No attempt has been made to cover this material in our bibliography. Rather, at the end of this report, along with the geological references, we have given a limited list of titles, by which the reader who is specially interested in the human aspects of our region may be guided to further inquiry. We shall use such space as we have in outlining early occupation, the location and development of centers of population, the use of the soil, the facilities of transportation and the initiation of manufactures.

### Sites and Trails of the Mohawk Indians

The Mohawk Indians are said to have entered the valley which bears their name in modern times, because they had been driven from their seats in the St Lawrence valley. They found in the valley above Schenectady a congenial home because there was much fertile bottom land where they could raise their corn, pumpkins, beans and tobacco. After the whites had settled in the Hudson valley the Indians found themselves conveniently located in reference to the carrying place of Schenectady and the markets of Fort Orange. They were also near to the fishing of Saratoga lake and to the old and familiar trails that led to Lake George and to Lake Champlain.

We reproduce from Dr W. M. Beauchamp's map of aboriginal occupation (fig. 9) a section which includes our four quadrangles.


Figure 9 Early and recent sites of the aborigines of New York.

We take in also considerable territory outside in order to place our region in its general setting. The area reproduced, beginning on the east below Schenectady, reaches beyond East creek and includes most of the Indian sites between Utica and Albany. The localities include villages, fortifications, burial places and work sites and caches of implements. Most of them are within a few miles of the Mohawk river. The sites are numbered by counties. We shall note a few of the localities but the reader who would gain fuller knowledge is referred to Doctor Beauchamp's report ('00), in which, under the several counties the author summarizes the main facts. Most of the sites in our territory are in Montgomery county, with a few in the counties of Schenectady, Saratoga and Fulton.

Driven from the St Lawrence by Hurons and Algonquins about 1550, the Mohawks came to the hills about the Mohawk, the junction of Schoharie creek and the Mohawk river being central to their various settlements. Here they were the easternmost of the tribes which had recently formed the League of the Iroquois, whose people held the Long House from the Hudson to the Niagara river. The Mohawks are said to have secluded themselves at first in locations among the hills for security from their enemies. Later they ventured down to the attractive bottom lands along the river.

West of Fonda the sites are numerous on both sides of the river, not only in the Fonda quadrangle but in the adjoining Canajoharie area. One mile north of Sammonsville was a stockade on the east bank of Cayudutta creek. This is number 3 of Fulton county and is fully described by Reid ('01, p. 6–11). A Mohawk village (no. 14, Montgomery county) lay south of the Cayudutta on the Fonda wash plain. This was the scene of a successful defense by the Mohawks against their enemies the Mohicans (Reid, '01, p. 181). There was a village near Yosts Station and there were other sites in this neighborhood. To the east there was a late Indian village at Tribes Hill.

On the south of the Mohawk there was an important settlement at Fort Hunter and the "lower castle" of the Mohawks was west of Schoharie creek near its junction with the Mohawk river. Another castle was at or near Fultonville. There was a village site with a cemetery near Auriesville (no. 26) and a village near Mill Point on the Schoharie.

Rock paintings were made by Indians on the north bank of the river at Amsterdam (no. 29). Flints have been found in the eastern part of the town of Amsterdam and at various points north-

west of Schenectady (nos. 1, 3 and 5, Schenectady county), in Glenville and near Pattersonville.

Arent Van Curler's journey in 1634 took him through our part of the Mohawk country and aroused his admiration. Many things conspired to make this impression — rugged relief softened by forests which were broken only here and there by fields of the red man, and the silver ribbon of the Mohawk winding between the forests and slopes on the north and the south.

Several aboriginal trails cross our area. First is the great central Iroquois trail leading from Albany to the west. It was trod by Indians, deepened by footsteps of discoverers and pioneers and was the forerunner of the trunk line of communication today. This trail split at Schenectady, following both the north and the south banks of the Mohawk river.

The south bank was much used in aboriginal days because there were the three chief Mohawk castles and attendant settlements, the lowest being near the mouth of Schoharie creek. The trail on the north bank diverged at Tribes Hill to Johnstown and then led back to Caughnawaga (Fonda). Singularly, one would now have to pursue a similar course to go by electric car from Tribes Hill to Fonda.

A branch trail left the main Mohawk path at Fort Hunter, led up the Schoharie and Cobleskill creeks and thence to the trails that followed the Susquehanna river. The Kayaderosseras trail began at Fonda and conducted the red man on missions of peace or war, through the township of Amsterdam, then northward through Galway and Providence to Lake George and Ticonderoga. Johnstown is on an old Indian trail that led northward through the Sacandaga country to Canada. If we had a complete map of all the primary and secondary paths of the Indians in our region, we should no doubt have a fairly complete plan of the main avenues of transportation today. Originals are as hard to trace in this field of human activity as in the interpretation of physiographic facts.

### Early White Settlements

Fort Orange (Albany) was established in 1623 and not many years later a Dutchman, Arent Van Curler, made the first recorded exploration by any white man, of the Mohawk valley. In 1662 Schenectady was founded at the gateway of the valley, by Van Curler and others. Beginning there a peninsula of advanced settlement was projected up the Mohawk for 16 miles, having a width of eight miles. Nearly all this tract, with the Mohawk as its axis, lies

within our territory. This new peninsula of population was to be preeminently Dutch, and the western limit as then laid out was not far from Cranesville, below Amsterdam. It is worthy of note as being the first push of the white man into this unique gateway of the northern Appalachian highlands.

From Pearson's History of the Schenectady Patent, we here record the names of men who were early possessors of lands on the north side of the river, between Schenectady and Cranesville. The names include Viele, Joncker, Van Hoeck, Vynhout, Schermerhorn, Peek, Kleyn, Marinus, Groesbeck, Mebie, Vander Volgen, Toll, De Moer, Van Coppernol, Swart, Van Eps, Wemp, and Groot (later known as Groat).

Farther west on the north bank, and on the south bank as well, the pioneer record leads us back to the Dutch of the Netherlands, New Amsterdam and the Hudson valley. Sammons, Schenck, DeGraff, Van der Veer, Fonda, Yost, Visscher and others are names, many of which would be found in any telephone list along the river as far west as Canajoharie and Fort Plain. It is the part of other works to describe some of their memorials. A symbol of this Dutch permanence is the Mabie house at Rotterdam Junction, built in 1670, bought by Jan Pieterse Mabie in 1706, and since that time a family possession. The Van Eps family were the first to settle at Hoffman and in 1923 the seventh generation was in ownership of the ancestral land.

The second population group which made a defined and notable entrance into our territory was the Palatine Germans. Dissatisfied with the arrangements on the Hudson, they migrated without the permission of the constituted authorities to the Schoharie lands in 1712 and 1713. After a winter journey of incredible hardship, they settled among friendly Indians. Here their titles to the lands were disputed by claimants of prior rights. From 150 to 300 families, according to various opinions, were concerned here and another emigration, farther up the valley, followed. We are here primarily interested in the fact that a considerable number of families remained on the Schoharie and have become a part of the permanent population.

They have left little or no impress on the geographic names of our quadrangles, but a little to the west and extending up to their new home at German Flats (Herkimer) these memorials begin to appear on the map. In the Canajoharie quadrangle we find Palatine, Palatine Bridge and Palatine Church. This second wave of white immigration swept across our area and came to rest in the

middle section of the Mohawk valley. Those who remained on the Schoharie recall to us the hardships of their native Rhineland, the uncertainties of their sojourn in England, their suffering on the Atlantic, their virtual slavery on the Hudson and the large place in State and Nation attained by their descendants in the Mohawk valley.

The most notable immigrant to our region from the British Isles and one of the greatest characters in American colonial history was Sir William Johnson. More than any other man he held the Iroquois Indians loyal to British interests against French encroachment from the north and west, and more than any other person he promoted British immigration into our region and made white residence in the Mohawk valley safe and profitable. He died before the Revolutionary War began and the allegiance of his son, Sir John Johnson, to the crown, made possible the persistence and extreme bitterness of border warfare.

It is no part of our plan here to sketch or estimate the career of Sir William. We desire simply to refer to the lands which he owned and the structures which he built, as geographic units of our area. They are of peculiar interest from the point of view of historical geography and can not be made known too widely to those who travel in our territory.

Sir William was of distinguished Irish lineage, with a strain of French blood. He came to America, a young man, in 1738, to superintend the lands of his uncle, Sir Peter Warren. These lands were east of Port Jackson and extended south from the Mohawk river. The settlement was known as Warrensbush and has long since disappeared. It is the first among the sites connected with Johnson's career.

In 1742 Sir William removed to the site now known as Fort Johnson, near the mouth of a creek, three miles west of the business center of Amsterdam. Here he soon built and occupied for many years the house which is now the home of the Montgomery County Historical Society. The stream, which had made deep cuts in the glacial drift, gave him the opportunity to erect a gristmill and a sawmill. This is the second Johnson site. In 1766 he built for his nephew, Guy Johnson, a stone mansion which stands in the western part of the city of Amsterdam between the railway and the river. It is known as Guy Park, is owned by the State and is used by the Daughters of the American Revolution. In location, though not in historic order, we call it our third Johnson site.

Restricted, as it would seem, by other patents, from acquiring lands near Fort Johnson, he with others secured the Kingsborough patent, taking up a large tract where Johnstown and Gloversville now stand. He built in the edge of what is now the city of Johnstown, Johnson Hall. He removed there about 1763 and there in manorial state he spent the remaining years of his life. He built a jail and a courthouse which are still in use, and in his home, conferences with Indians, visits of distinguished whites and affairs of wide import set apart this fourth Johnson site to historic fame.

Fond of sport, he built "Fish House," a summer home, on the southern bend of the Sacandaga river, where the village of Northampton now is. This house was burned in a raid from the north, by his son, Sir John Johnson, in 1780. This is our fifth site and a sixth is in Broadalbin township on whose ground he built another summer home.

We may see Sir William in other relations which are geographic. None better than he knew the remote trails of wide forests, but we cite simply the journey which he made, carried by Indians on a litter, from Johnstown to the springs of Saratoga. Late in life and ill, he yielded to the hopes of his red brothers that these waters might be curative. We picture him on a forest trail where now a paved turnpike passes through Broadalbin, Barkersville and East Galway to Saratoga.

No other local result of his career is so notable as his agency in bringing large numbers of Scotch from the north of Ireland, to place their stamp upon parts of the Fulton and Montgomery counties. He is still the historic figure of our region. In Johnstown are his grave and his monument.

North of the Mohawk river the early inhabitants were largely Scotch Irish and Scotch. We have noted Sir William Johnson's activity in securing some of these settlements. The names Perth, Galway, and Broadalbin are memorials of some of these migrations. Reid ('01, p. 239) is authority for the statement that 400 kinsmen of the men active in the bloody affair of Glencoe settled in the valley of the Mohawk. Charlton and Galway were settled by the Scotch in the years just before the Revolution. Some of them came from Galloway, hence the township name "Galway." This town was formed from Ballston in 1792 and was first called "New Galloway." Slightly later others came and settled southward from the men of Galloway, in what is now Charlton. This settlement then became known as "Scotch Street." Gilchrist, Bell, McKinney and McWilliams will be recognized as names appropriate to this group. Bunyan,

Hume and Gordon are other names of the same sort. Colonies from Rhode Island and also from New Jersey settled in Galway. Thus early began in our region those national mixtures of neighbors and of biological inheritance which so long and so widely have characterized the United States.

The hilly and mountainous towns of Providence and Edinburg were more attractive to settlers in those early days when isolation counted less in human feeling than it does today. Sawmills, gristmills and tanneries based on the water power, forests and hilly fields, found active business and built up a diversity which is not possible today. The period of abandoned farms, town life and mass production was yet far away.

John Sumner came from Connecticut to the Sacandaga river in Edinburg and his son John built a sawmill at Batchellerville before 1800. The father was a cousin of the statesman, Charles Sumner. A descendant of this household who is still living in Edinburg, was for long the proprietor of a lumber mill and has recently communicated information to the author of this report. Another settler in this town, possibly the first, was a son of General Stark, the victor in the battle of Bennington.

The names of town officers in the towns of Providence and Edinburg for a century show the prevalence of English names; one finds himself there beyond the domain of the Dutch, the German and the Scotchman. These items give samples of what happened in the evolution of the early population of our region. They are not given as outlining local history but as illustrating the mixed beginnings of life in a new environment.

The special period of the New Englander in New York did not arrive until after the Revolution. Then the men of the East began to pour in. Some were attracted by confiscated lands of the Loyalists, and soon a great procession was crossing our area to central New York, to the Genesee country, to Ohio and beyond.

## Battle Grounds

All land west of Albany, until 1772, belonged to Albany county. In that year under the influence of Sir William Johnson, Tryon county was formed. It extended up the Mohawk past the colonial settlements and into the wilderness. Northwestward it found its limit on the shores of Lake Ontario and the banks of the St Lawrence river. The eastern border of Tryon county was the eastern limit of Montgomery, Fulton and Hamilton counties. The name was changed to Montgomery county in 1784, because Governor Tryon was

hated for his British sympathies. General Richard Montgomery, killed at Quebec in 1775, was honored in the choice of the new name. The county was reduced in size from time to time and assumed its present limits in 1838 by the setting off of Fulton county.

Tryon county in American history is a synonym for the strife of neighbors and the shedding of blood in the border wars. Before noting the sites of Revolutionary conflict we shall refer to one well-authenticated battleground of Indian against Indian.

Above Hoffman Ferry rises a mass of hills in the town of Glenville, attaining a maximum altitude of 1097 feet. Wolf hollow cuts through these hills and here the Chaugtanoonda creek enters the Mohawk. This gulf marks the line of Hoffman fault and by its shaded roadway are the rocks tilted in that disturbance of ancient geological time. The south end of the uplift reached to the river and was carved into a rocky cliff in grading for the New York Central Railway (fig. 16).

The great hill was known to the red men as Towereune. The Mohicans in 1669 tried to reconquer the territory from which the Mohawks had driven them. They attacked their old enemy at Caughnawaga (Fonda) and were driven off. They made their stand on the Glenville hills which offered a defensive position by reason of the faulted spur that descended to the river. The Mohicans were here attacked, defeated and many of them destroyed by the fierce fighters of the Mohawk tribe. The Mohawks called this spur Kinaquariones, and gave this name to the battle fought there.

The first deed of violence done in our region, indeed in the whole Mohawk valley, took place at Caughnawaga in 1775. Colonel Guy Johnson, in company with other Loyalists, made a violent speech. Jacob Sammons defied Johnson and was knocked down by him, bearing thus the first scar of the years of border warfare. Sampson Sammons, the father of Jacob, was a member of the Tryon County Committee of Safety and they as a family shared in the battle of Oriskany and the sufferings of a Canadian dungeon. Early in 1776, 3000 patriot soldiers were reviewed on the ice of the river, preparatory to a movement on Johnstown. This is said to have been the largest Revolutionary force ever assembled in the valley.

The Mohawk valley for many miles in the vicinity of Tribes Hill and Fonda was raided in May 1780 by Sir John Johnson, with Tories and Indians. It was a scene of fire and massacre which makes it impossible for the people of the valley to recall the son of Sir William Johnson other than with horror.

Currytown is a small village about three miles south of the Mohawk river at the Noses. On June 30, 1781, this hamlet was raided by 300 Indians and a few Loyalists. Fire, massacre and capture were the means used. The invading party was pursued and defeated at Sharon Springs, which is several miles outside of the region of our study.

The same autumn, 600 men, Indians and Loyalists, came down the valley and did a work of killing and fire at Warrensbush, the very place where Sir William Johnson had begun his American career. Retiring before colonial troops that came to the rescue, the British force took up a position at Johnstown. Here was fought a bloody battle, the last Revolutionary battle in New York. The contestants did not know that Cornwallis had a few days before surrendered at Yorktown. In the pursuit by the victorious colonists, Walter Butler, one of the most abhorred men in American history, was killed.

It was in the immediate valley of the Mohawk therefore, and localities within a short distance from the river, that raiding and fighting occurred. In any war affecting the northeastern states the Mohawk, Hudson and Champlain valleys would be strategic ground. At the end of the Revolution there were in Tryon county, sparsely as it had been settled, 380 widows, 2000 fatherless children, 12,000 abandoned farms and the sites of 700 burned buildings.

### The Larger Centers of Population

Geography in the schools of Europe and for a shorter period in those of our own country has become something more than a description of the courses of rivers, of the trend and height of mountain chains, of the size and industries of cities, of the products of mines and fields. It is now primarily a study of relations and causes, of the adjustment of human life to the lands, the waters and their resources.

Environment is a composite of relief, soils, climate, natural routes, the resources of the forests and the superficial parts of the earth's crust. If we enumerate these things, it is that we may trace the outcomes of life and society so far as they proceed from physical conditions. Along with the physical environment there come the movements and mingling of races and nationalities in their historic order. To a certain degree geography takes account of these considerations also, without departing from its proper field.

In the above sense any village, with its site and surroundings, its houses, churches, schools, general store and small mechanical crafts, becomes a worthy theme for intensive study and leads into the field of large relations and general principles.

It is upon considerations thus briefly stated, that we give and analyze some of the facts about the cities and larger villages in our field of study. We have space for but a brief outline, a sort of skeleton which might be clothed with flesh and given full life and expression. In countless ways the serious reader who may be a resident, knowing and loving the place and its life from childhood, can fill in with details not known to the present writer. In particular it is hoped that teachers of geography and of history may be helped to ground the study of State, Nation and the world at large in those humble but not less significant things that can be found at home. The features of the physical environment, the historical geography of municipality, town and county, the growth of industries, the changes in population—all these features as related to any center here described offer material for class work and goals for excursions and observations in the field.

## Amsterdam

Villages along the Mohawk were commonly located at the mouth of lateral streams. In such situations there was usually an extension of the ordinary flood plain and a larger area of tillable soil. There was water power also, afforded by streams which were not too large to be harnessed and controlled by the pioneer. In the general rejuvenation of surface and blocking of the ancient mature drainage of preglacial time, we have the explanation of the abrupt descent of water within short distances.

Illustrations of these principles in our area we found at Pattersonville, Cranesville, Amsterdam, Port Jackson, Fort Johnson, Fort Hunter and Fonda. The beginnings at the mouth of Chuctenunda creek were not made until settlements had been established at Warrensbush, a settlement on the lands of Sir Peter Warren, uncle of Sir William Johnson, south of the Mohawk river, east of Port Jackson, which has long ceased to exist; Cranesville, and Fort Johnson. Cranesville was settled by Philip Groot, or Groat, in 1730. A gristmill was built at once and is said to have supplied flour to a distance of 50 miles.

William Johnson, afterward Sir William, came as a young man to the Warren estate south of the river in 1738. About 1742 he built Fort Johnson and erected there a sawmill. A gristmill was added in 1744 and Sir William lived there until 1763, when he removed to the manor house which he built at Johnstown.

The first settler where Amsterdam now is was Albert Veeder or Vedder. He built a sawmill and a gristmill and the place was first called Veeders Mills, then Veedersburg, and after 1808, Amsterdam,

using the name of the township which had been set off some years before.

The Chuctenunda creek is many miles long, has ample waters and descends as a swift torrent over rocks from which it long ago stripped off the cover of drift. It did not, like the creeks at Fort Johnson and Cranesville, reoccupy a mature valley. Hence it joins the Mohawk not at grade but by a dash down a rocky slope. It thus concentrates its fall, and power sites stand close together. The name refers to the rocks, not probably those of its bed, but to outcrops on the north bank of the Mohawk near its junction of the waters. These outcrops were a traditional place of shelter to migrating Indians before the white man's advent.

Amsterdam began the nineteenth century with 100 inhabitants, was incorporated in 1831 and became a city in 1885. The river was crossed by a ferry until 1821, when the first bridge was built at that point.

One writer, on the beginnings of Amsterdam, says of the Chuctenunda neighborhood that "the territory was barren, and bare rock was more in evidence than fertile soil." To the west of the "cross-roads," the land was in the main "sterile, rocky and swampy." This must have been west of the present intersection of Main and Market streets. There were boulders no doubt, unremoved since the Iroquois waters freed them from finer drift, and the surface was boggy, a widespread condition following the glacial obstruction of drainage, which we fail to realize now that forests are down, the sun shines in and man has graded and drained the land.

Rev. John Taylor visited Amsterdam in 1802 after some development had taken place, observed the place from a different angle, calling the Chuctenunda "a very fertile and useful stream," and proceeded to enumerate the oil mills, gristmills, the sawmills and "one iron forge."

It is not difficult to see why Amsterdam has become the major community of the region which we have under observation. It was on a route of transportation, which, taking account of all its closely parallel lines, is not equalled elsewhere in America. It had the most ample water power in the district. This power fell far short of future needs, but it set the town upon its industrial career. As a market town it is centered upon an area of soils derived from limestones and black shales, an area which extends both ways along the river and for some miles to the north and south.

Here a bridge was early built across the Mohawk and soon after, the Erie Canal was constructed along the south shore. Port Jack-

son became a depot on the canal and was a convenient port for Amsterdam.

The form assumed by the city in its growth has responded to physical conditions. Forced by expansion, it has crept up the steep slopes which were made by the undermining of Iroquois waters, reaching farther north along the water power sites of its turbulent stream. Nature has not made it easy to go from river to upland, but has fostered east and west elongations on the narrow riparian strip until now solid settlements reach from Fort Johnson to a point far below the old four corners. It is six miles from Sir William Johnson's mansion to Cranesville and the ancient holdings of the Philip Groat family. At least three-fourths of this distance is now filled with homes and shops.

Paved roads now run east and west on both banks of the river and very directly reach Saratoga Springs, Northville and the Adirondacks, Gloversville and Johnstown. Surfaced roads likewise lead over the southern plateau to the Cherry valley turnpike and the northern Catskills. The development of transportation will find place in a later section of this report.

As with most cities in a glaciated region, Amsterdam depends closely upon conditions of the drift for its municipal supply of water. The growing populations of the city and the adjoining districts have produced increasing contamination of local waters and made necessary more remote sources of supply. The wells and pipelogs of a local water company supplied the village until 1881. Then Rogers, McQueen and Bunn creeks were taken into requisition, the two former unnamed on the topographic map, uniting in the stream that enters the Mohawk at Fort Johnson. Bunn creek joins the Chuctenunda near the Sanford Carpet Mills.

In 1889, when more water and more perfect sanitary conditions were required, Hans creek was selected. This stream has many miles of flow through a forested region in the town of Providence. There are three reservoirs at a distance of 15 miles from the city, Glen Wild, Cook's reservoir, and Little Round lake. They are fed from a watershed of about 23 square miles, owned by the city, the total capacity of the reservoirs being 1,400,000,000 gallons. A 24-inch pipe, with gravity flow, brings the water to a distributing reservoir in the city and to 65 miles of water mains.

In the geological sections of this volume we have made many references to the various forms of the glacial drift in and near Amsterdam. Many of these are open to the observation of school groups or other interested persons. The principal cemeteries, Green

Hill, St Mary's and Fairview, are all located upon the belt of washed drift on the upper hillside and as we have seen, show conditions of deposition in glacial waters. Sands with porous glacial subsoils are often sought for places of burial, and here we have no exception, although, as we have seen, the conditions of deposition were so shifting that the character of subsoils at any particular point is not surely predictable.

Some exposures of drift are much obscured by the wash and the plant growth of many years, as along the Yankee hill cut and in the great pit north of Guy Park avenue, but many localities of glacial and physiographic interest are still available. Such are the gorges above Cranesville, Hoffman, Fort Johnson, and along the Danascara creek, all these being north of the river. South of the river is the postglacial gorge above Port Jackson, and the great ravine three miles eastward. In Port Jackson are the fresh sections of brick clay, whose fine particles settled in waters that still bore icebergs from no remote glacier. Silts in lake waters made the fine platform which constitutes the southern part of the Antlers golf grounds. The teacher will not fail to find in the drift, the glacially scratched, or water-worn fragments of the limestones of the valley and the cobblestones and boulders which betray their Adirondack origin.

### Fonda and Fultonville

The Indians chose their site in the eastern end of what is now Fonda and they called their village Caughnawaga, a name apparently referring to a rift or rock in the river. They chose with their usual keen sense of geographic values. There were flood plain lands on both the Mohawk and Cayudutta, and similarly easy of cultivation was the Fonda wash plain just westward. They were at the opening of a route northward to the fishing and hunting of Canada lake, the Sacandaga river and the Adirondack forests.

When the white man came he found the further advantage of good mill sites on the Cayudutta. The first settlers were Dutch and they came between the years 1715 and 1720. They began at Caughnawaga and extended their lands and houses westward toward the mouth of the tributary stream from the north. Among the earliest Dutch names were Fonda, Wemple and Vrooman. Douw Fonda, who was killed and scalped at his own home in a Revolutionary raid, had a trading post where is now the Montgomery county fair ground between the New York Central Railway and the Mohawk river.

Fonda's name was given to the village and his son, Jelles Fonda, was even more widely known as a trader and influential citizen. It was here that Jacob Sammons had his encounter with Colonel Guy Johnson.

After the close of the Revolution Fonda ranked with Herkimer as one of the two chief places on the north bank of the Mohawk river west of Schenectady. It had better access to the north than the site of Amsterdam, which was settled later, and its fields were wider and more easily tilled. The factors of more available water power and larger human initiative later sent Amsterdam ahead in the race.

The permanence and growth of the village were assured between 1830 and 1840. The Utica and Schenectady Railway was completed and Fonda became more than ever a point of departure for the towns of Fulton county and in later years for the hunting grounds and summer resorts in the north. In 1838 Fonda became the county seat of Montgomery county.

The teacher of geography in Fonda and its vicinity has available many good illustrations of the principles of the subject. Such are the stream phenomena of the Mohawk and Cayudutta, the wash plain west of Fonda, "Teaburg" in Fonda, the ancient landslip to the eastward, Danascara gorge and the gorge of the Noses, the great escarpment and the alluvial cones near Yosts. On the human side there are the several means of transportation by land and water, the local industries, and several historic sites and buildings among which, near at hand, is a structure suggestive of the border wars, the home of the hated Butler family.

Still another unit in this group of geographical and historical facts is the water system of Fonda. Its source of supply is four miles west of the village, including a group of springs and a small stream, all of which originate high up on the rocks of the "Big Nose." An earlier system was installed about 1890, and the present system came into use after the opening of the present century.

Both of the principal burial places are on the high-level deposits of washed drift, one being on the Fonda wash plain west of Cayudutta creek, and the other on a remnant of deposit of the same nature north of the village.

Fultonville started and made its growth because its site is across the Mohawk river from Fonda. A ford and later a bridge established its communication with the route of travel and mail carriage, running east and west through Fonda and northward to Johnstown. Very early its only house was an inn where traveling Indians made

their stopping place, and from which the mails reached the routes north of the river.

The main development came with the construction of the Erie canal, which made it a port and depot for Fonda and the Cayudutta basin as well as the chief trading place in the town of Glen. It became the southern terminus of the plank road which was laid in 1849 through Fonda to Johnstown.

## Johnstown and Gloversville

It is an aid to brevity to treat these cities together. They are closely related to each other in situation, history and industries. Each merges into the other along the same small stream. Each center under the spur of larger population and growing needs secured direct communication by rail with Amsterdam, Schenectady and Albany. Taken together their names are everywhere known and they perhaps offer the best illustration in America of community concentration on a single industry. On the fringe of the larger and younger city is the settlement bearing a designation that is older than the name of either.

In the physical features there is some diversity. Johnstown has many of its streets on a great drumlin, at whose base run the principal business thoroughfares. The central parts of Gloversville are on the sands of the interlobate moraine. On the north and west Gloversville streets, at least several of them, run up the slopes of drumlins. Johnstown has several drumlins near at hand. In the eastern section Gloversville is occupying flat ground that seems to have been deposited in rather temporary waters, perhaps held there for a time by barriers of stagnant ice. These contrasts and resemblances between the sites of the two cities can be seen by observing the glacial map. To go east or west from Johnstown is to pass among drumlin contours. To go directly east from Gloversville is to enter the semidesert, which in a narrow belt heads toward Broadalbin.

North and northwest of Gloversville one finds a great sea of drumloid contours, although many of the hills are not colored on the map as drumlins. Around and west of Meco and up and over Clip hill stretches the confused morainic aggregate, as we follow it westward. It carries poor soil and poor houses with it, as it rises over the Noses escarpment and leaves the quadrangle.

Gloversville is near the Adirondack goals of travel, toward which hard roads run out to Caroga and Canada lakes, to Mountain lake and about Bleecker and to Northville. Both cities are on an ancient trail that led up the Cayudutta and on to the Sacandaga and the wilds of what was to become Hamilton county.

Both cities lead us back to Sir William Johnson, through the Kingsborough patent of 20,000 acres of wilderness, which he and others, doubtlessly he chiefly, obtained. Johnstown derives its name from his and is far more directly related to him, since Gloversville as a municipality dates many years after his death. A Geographical History of New York published about 1850 mentions Kingsboro, then Gloversville, and gives to each a population of 400.

Johnstown was settled by Sir William Johnson in 1759 but did not receive its name until 1770. Sir William leased or sold lands to more than 100 families. Among them were Dutch, German, Irish and Scotch immigrants. Although but a few miles from the Mohawk, the dominance of the Dutch here gives way and the national origins make a different composition of the population.

Johnstown, although the residence of its founder during a period much shorter than the time of his life on the Mohawk, has the most numerous memorials of his presence. This was natural because here he established a manorial seat, in the years of his widest influence and greatest wealth. Here therefore we find Johnson Hall, erected in 1762, the courthouse dating from 1772, the jail of the same date and some other buildings erected after Johnson's death but before the end of the century. Here also are his grave and his monument. The battle of Johnstown was fought within the limits of the present city.

The manorial house, Johnson Hall, belongs to the State of New York and is in the custody of the Johnstown Historical Society.

Johnstown is surrounded by fertile agricultural lands, of rolling surfaces and very commonly molded into drumlins or drumloid forms. Across its site, along what is now a branch of Cayudutta creek, flowed the outlet waters of glacial Sacandaga lake, and the point of emergence from the lake at the head of Skinner creek is but six miles east of Johnstown.

Gloversville has abundance of arable land on the north and south, but to the east and west are the sandy hills of the interlobate moraine. Neither city has depended in the main on the trade of the environing farms and villages, for remote domestic and foreign trade in skins and gloves has given them wide commercial relations. Yet we are told quite amusingly by a writer of the middle of the last century that Fulton county had "no commerce, from the want of navigable streams." Yet in the same paragraph was recognized the manufacture of leather, gloves, flour, lumber and paper.

The Johnstown water supply proceeds from the Noses uplift, but from higher altitudes than for Fonda. The Warren, Cold Brook

and Cork Center reservoirs have altitudes of 924 to 1054 feet above sea level, while the street levels in Johnstown range from 650 to 750 feet. The two first-named reservoirs are smaller and join the city by a ten-inch main. The Cork Center connecting main has a diameter of 16 inches. The two supplies are independent of each other and afford ample pressures. In an interesting relation to the sandy morainic soil of the watershed, the city is planting the surface with tens of thousands of Scotch pine.

Gloversville has had a municipal water system since 1877. Various works in different years have been built on Rice creek, Mayfield creek and Port creek. It will be seen by the map that their watersheds lie north of the city along the base of the Adirondacks, the distances of the works from the city being from three to ten miles. The reservoirs are from 280 to 345 feet above the city and are eleven in number.

The origin of the glove industry and its relation to this environment will be noticed in the section on the rise of industries.

### Broadalbin and Northville

The village of Broadalbin rests mainly on a platform of washed drift. On the south are the flood plains of the Kenneatto creek and beyond the creek, slopes rise to the wide surfaces of the Perth till plain. On the north is a belt of hills by which the interlobate moraine continues eastward. Broadalbin will be barely a half mile east of the southern extension of the Sacandaga reservoir. The site has long been favorable for settlement because of its connections by trail and roadway. It is on the direct route northward from Amsterdam to Fish House and the Sacandaga river. Through this site or close to it ran the trail from Johnstown and the west to Saratoga Springs, a route now followed by a paved and much frequented highway. It has the crossroads type of situation.

Broadalbin well illustrates the national diversity of the pioneers. The first settler in the neighborhood was a German, Henry Stoner, who came in 1770. He was killed and scalped by a red man and his son, Nicolas Stoner, became famous as hunter and Indian hater. The village had its beginning just before the Revolution, with such names as Bowman, Putnam, Salisbury and Cady. Later came Samuel Demorest, a Hollander, and Alexander Murray, from Scotland. Chalmers, Blair, Campbell and Stewart are other early names, and then the community was infused with men of English lineage from New England.

The various names of the village tell the same story. At first it was Kenneatto, then it was long known as Fonda's Bush (Fonda's

Woods) from Jelles Fonda, the aggressive Dutchman of Fonda. Through Dutch influence in the Legislature it was incorporated as Rawsonville, from an early physician, but the place was never organized under the name. A prior name, given to the post office in 1804, gained the ascendancy. This was Broadalbin, from "Breadalbane," the name of an ancient jurisdiction and family in Perthshire, Scotland.

Northville has a situation whose physiography is unusual. It is bordered west and east by the Sacandaga and one of its branches. On the north rises a mountain spur. It stands on a terrace which is part of the delta of glacial Lake Sacandaga. North of the village at the base of the mountain is a high sand plain on which is the village cemetery. Across the river westward, Sacandaga Park stands on another piece of the delta. The river has cut away the sands and gravels which once joined these two sites. North of the village, along the river, is the head of the delta, with its accompanying moraines, as already described. A mile west of Sacandaga Park are the moraine and spillway at the head or southern end of Gifford valley. On every side except the north Northville will look out upon the waters of the Sacandaga reservoir. A short distance up the hill eastward, also a mile north, the interested student will find glacial striae on the bed rocks near the roadway.

It was natural that Northville should be settled later than the other main centers. Its two principal streets were laid out in the last decade of the eighteenth century. A gristmill, a sawmill and a tannery were wholly appropriate as early industries. In particular Northville later became the center for an immense log trade, for it was the gateway to the forests of Hamilton county and by it on the Sacandaga waters logs moved to the Hudson river, Glens Falls and beyond.

Northville is still the gateway to northern forests, now not so much for logs to pass out as for men to pass in. The tourist and the summer resident reach northern resorts by way of Northville. So many also sojourn in Northville and in Sacandaga Park that we may properly speak of the summer resort industry as definitely engaging the interest and providing the support of many of the permanent residents. Conditions of uncertainty have now arisen through condemnation proceedings and the changes in land and water that will follow from the making of the new reservoir.

The municipal water supply comes from a lake in the hills two miles north-northeast of the village. A similar supply of soft mountain water is drawn by Sacandaga Park from a small lake three miles to the westward.

## Soils and Agriculture

In the human geography of any region the basal fact is its agriculture. Here also is the bond of most intimate dependence of man upon those physical conditions which largely shape his life. We must recall to the reader the large facts of relief which found place in our account of the physiography.

In the northern parts of the two northern quadrangles are large areas of the Adirondack crystalline rocks and of only partially deforested land. In the southern parts of the Amsterdam and Fonda quadrangles we find a sandstone plateau. On the west are the uplifted lands and steep scarps of the Noses fault. On the east are the high and rugged hill masses of Rotterdam and Princetown. South of the Mohawk river and in Glenville on the north we find the uplift of the Hoffman fault and the highlands lying to the eastward.

The favorable lands for tillage form a central area on both sides of the Mohawk. Geologically the fields of this area rest upon and have developed from formations of limestone and shale which have afforded soil elements in richness and abundance. This is true by reason of the character of the local bed rock and because the drift formations have tended to concentrate on the lower levels along the Mohawk, extending a short distance south of the river and to a greater distance northward. In sketching agricultural conditions we must remember also that the altitudes of the surrounding highlands have given them a severer climate and a shorter growing season than belongs to the central area. The latter has been favored by the larger growth of population and better means of transportation, affording both local and more remote facilities for marketing the products of the soil.

Viewed in reference to several parts of counties included in our area, we observe that Montgomery county has its eastern half, or somewhat more than half, in our field of study. The same is true of Fulton county. Montgomery county has much the greater area favorable for tillage. In Saratoga county our area includes parts of the towns of Galway and Charlton, where agricultural conditions are favorable. In Fulton county the same may be said of the towns of Johnstown, Mayfield, Broadalbin and Perth. Some sections of the towns of Glenville and Rotterdam in Schenectady county furnish good farm lands. Here are included bottom lands of the Mohawk, early utilized by both Indians and whites up to the county line near Hoffman Ferry.

Montgomery county is the only county in which our area has a share, which has been subjected to a survey by the Bureau of Soils of the United States Department of Agriculture (Lee and Lounsbury, '09). The discussion which here first follows is therefore confined to the eastern portion of Montgomery county, extending from the eastern boundary to the uplift of the Noses. The authors of the survey here cited say that Montgomery county, in the heart of the Mohawk valley, "doubtlessly represents better than any other one county the soil and agricultural conditions of this region."

Both the Indians and the early whites were attracted to the region by its natural fertility, its beauty and its accessibility along the trails and waters of the Mohawk valley. The Indian fields were on the flats and there were a few orchards on the uplands, comparable in character if not in numbers to the Iroquois orchards of the Finger lakes region. Flax and wool were early products in days when each family must provide for most of its needs. The maximum of sheep production was in 1860, followed by a long decline. As in so many other farm regions of the East, wheat has since 1880 yielded to other crops, urgently required by the growing population, while the breadstuffs are more cheaply secured from western fields. In 1850 the chief grain crops were wheat, oats, corn, rye, buckwheat and barley. Barley and rye are now little raised, and the same is true of hops. Montgomery once was counted with Otsego, Chenango and other counties of eastern-central New York as prolific in this crop.

Oats are still the largest grain crop. Corn also has a great acreage, but much of it is grown for ensilage and not for the dry grain. Buckwheat retains its place because it is well adapted to the soils and climate of the high southern areas. Hay is a leading crop because the dairy has become the dominant phase of agriculture. Before 1860 butter and cheese were the chief products of dairying, then made in the homes. Factories came in, transportation was improved, the cities of the Hudson valley grew and now the industry is mainly for the production of milk for shipment to greater New York and the cities of the middle Hudson valley. The three cities of our area and its villages have a population of 80,000 or more and offer an important market.

The dairy requirements now demand a milk supply of 12 months, without the old-time cessation during the winter. Silo corn and improved herds have made this possible. The soils and climate favor

grass and silo corn rather than grain. Thus we have a twofold geographic adaptation, to the capacity of nature and the demands of man.

The Mohawk series of soils is regarded as specially suited to forage crops, and the Volusia silt loam is well adapted to buckwheat (fig. 64).

Before we proceed to a brief notice of certain soil types and areas, as outlined in the Soil Survey of Montgomery County, it must be said that the report should be read with qualification in many passages in which the glacier and its waters are used to explain the origin of the soils. These passages are numerous, specific local evidence is not given, and erroneous impressions will follow implicit reliance upon them.

The authors assume that the motion of the Mohawk glacier was from *west to east*. In the light of our previous presentation we need not comment upon this error. Further, there can be very little "residual" soil in our area. The soils so considered are without doubt mainly derived from weathered glacial till. It seems to be assumed that most drift is foreign to the locality, whereas we now know that most of it is of local derivation. This principle is overlooked when it is stated that there is "no glacial drift upon the surface."

It is also probable that in regions of thick drift the underlying rocks have contributed more material to the soils than in regions of thin drift. The pages of the survey also place far too much emphasis upon the influence of glacial waters upon the soils of the upland areas. It is overlooked that the ice deposited much sandy till, and that strings of sand or pockets of coarse waste do not require the presence of a body of static water.

In general the authors of the survey have sought to place in the Mohawk soil series, soils derived from the weathering of the "glacial mantle," while drift worked over by water is assigned to the Dunkirk series. The last principle is much overstressed in the report.

It is possible in a general way to see a relation between some of the leading soil types as depicted on the soil map and the bodies of glacial and postglacial material as set forth in our glacial map.

The Genesee fine sandy loam stands for an alluvial soil and is therefore mostly found along the Mohawk river and Schoharie creek, in the flood plains of both and the terraces of the latter. These are

the most valuable farm areas in the region. To the Dunkirk gravelly loam are referred coarse soils as are found on the Iroquois gravels east of the Noses. Mohawk loam, Mohawk clay loam and Mohawk silt loam are names applied to various soils along the Mohawk, especially on the south, and reaching several miles into the uplands. They are all mainly derived from the underlying till, which in turn had its origin mainly in the limestones and black shales of the region. The last named marks a passage from the Mohawk clay loam to the Volusia silt loam, which is a pale, thin soil formed mostly of the thin glacial till of the sandstone uplands in the southern part of the district.

We have referred to the Dunkirk gravelly loam. Examples of Dunkirk coarse sand are cited as occurring on the Fonda wash plain and at Tribes Hill. Dunkirk fine sandy loam is mapped in many areas on both sides of the Mohawk, back for some miles. These soils even on the higher ground are ascribed to reworking in high-level, temporary lakes. This interpretation is more than doubtful, as these soils have in most of the upland areas been developed through the weathering of the till.

These remarks carry no criticism of the characterization of the soil, or of the agricultural adaptations and uses which are described or advised in the report.

The agricultural conditions of Montgomery county are well summarized in a letter to the writer from Chester W. Austen, county agricultural agent, and his statement is here reproduced:

With regard to our special farming conditions, Montgomery county is devoted very intensively to the dairy industry. As you may know and as you will also see from the folder, our soils are generally of the heavy type which endows our farms with those types of soils so desirable to hay, grain and good pasturage. Because our soils are heavy they are perhaps less desirable for some of the more diversified crop growing as in some of the surrounding areas like Albany and Schenectady counties. In the past Montgomery county has been a very extensive hay-growing region from which have been shipped thousands of tons of hay. Now that the hay market has tapered off, more of the one-time standing meadows are being devoted to more extensive grazing and the dairy industry is enlarging. Hay and grain and corn are being grown as always to make the farms more self-sustaining to the dairy industry. As a supplement to these crops, the Farm Bureau has instituted a program of growing mixed grains. Where up until five years ago practically all of the grain that was grown was oats, today we have

thousands of acres of the grain mixture of oats, barley and peas. This crop is being extensively raised to reduce the farmer's feed bill. Years ago this was a large cheese-producing section. Today it is all fluid milk. This is the transition that has taken place in the dairy industry in this county. At the present time we have ten or twelve shipping stations which are daily shipping out fluid milk. In one particular center, namely, Fort Plain, the fluid milk business for that town alone approximates more than a million dollars annually. This gives you some picture of the immensity of the income from fluid milk. There is but one cheese factory in the county at the present time and I understand that this is its last season, so that practically 100 per cent of the dairy business will forthwith represent a fluid milk product. This, in a brief sense, gives you some picture of the type of farming in the county. At the present there are about 30,000 dairy cows in the county and approximately 2000 farms.

We may observe finally as regards Montgomery county that while it is small in area, its agriculture in several respects shows high totals per square mile. This is notably true in the value of farm property and farm products, in the number of dairy cows, in tons of hay and bushels of oats. As a whole, few counties of the State surpass it in intensive farming.

## Sundry Natural Resources

When we regard human life as affected by the glacial invasion, we think first of soils. Upon these the kinds and distribution of crops largely depend, always taking account of climate and not neglecting the distinctive human elements of taste, need and competitive producers. Transportation also enters in and this depends both on natural features and upon human skill and initiative. Thus we see how difficult it is to evaluate so-called geographic influences.

Under agriculture we have not included the forests and yet more and more we are learning, and properly, to consider trees as a crop. The native forests of the Adirondack sections of our two northern quadrangles have in the past yielded large amounts of lumber, and the Sacandaga river was an important means of transport for northern logs. The supply, as everywhere in the East, is much depleted and lumbering in Fulton county has been decreasing for several years. The reservations by the State and the purchase of camps and estates account in part for this decay of an industry. We are informed that it costs more to get out the native lumber than to deliver western lumber with all charges paid at Northville. Thus it

is with lumber as with wheat: it can be produced, but not economically, in the face of mammoth production and facile carriage. There is some lumbering in Fulton county, the product being mainly used for minor structures and the making of baskets. Transport is by truck and wagon.

Glacial agencies have very directly conditioned the fragmental materials of stone used in the construction of buildings, roads and other public works. We have already named several openings for sand and gravel on or near the Mohawk river. Among these are pits at Fultonville, Amsterdam, Pattersonville, near Rector's Station and the Haverly pit at the eastern border of the quadrangle. There has also been considerable use of the kame deposits of Glenville and of the morainic sands in the vicinity of Gloversville.

The bed rocks which may be utilized have no special relation to glacial changes except that in some situations the preglacial residual deposits have been cleaned off and the oxidized and less desirable surface rocks have been removed, leaving the usable beds exposed, or at least near the surface. The most extensive utilization of the hard rocks is at the crushing plant across the river from Cranesville. Many quarries have been abandoned by reason of the growth of the concrete industry. Several quarries in the Broadalbin quadrangle are named in Miller's account of the rock geology of that area (see bibliography).

The waters of the region, whether in the form of streams, lakes, reservoirs or ground water, are closely dependent for their quality and distribution upon glacial conditions. Reference has been made to the water supply of several communities, which are all easily accessible to the higher and forested grounds, where the terranes are in general so free from lime as to give supplies of relatively soft water. The reverse is true of many small villages and farms where the ground water of wells and springs has taken into solution much lime from calcareous drift.

It is permissible here to include the conception of landscape, whether this expresses the more common aspects of plain, hill and valley, or the more striking features usually denoted by the word scenery. It is not amiss to consider landscape and scenic conditions as natural resources, not forgetting that these features have higher than economic values. Such resources are abundant in our area, and their varieties of altitude, of field and forest, of lake and mountain, are accessible by good roads to many millions of people. No

doubt several thousands in our area win their living, or supplement other income by what we need not hesitate to call the summer resort industry.

## Early Roads

In a region of strong relief such as we have under review, the major lines of movement usually follow the principal valleys. These valleys were in existence long before the glacial invasion. This is known to the technical student and can not be too strongly emphasized in the mind of the general reader. The ice greatly modified the surface in detail but did not revolutionize it. In our area the most striking change was the diversion of the Sacandaga river.

The character of roads and their detailed courses have, however, been closely dependent upon the glacial drift, its forms of relief and the nature and variety of its materials. This was especially true of the early lines of land communication, which were nothing but dirt roads, dependent upon soil, subsoil and natural drainage. The newer roads are less dependent upon the local conditions except as local materials are used and as special problems of construction arise.

We have already given a brief account of the Indian trails. The early roads departed little from the courses of these primitive paths. In a description of the country between Oswego and Albany in 1757 (O'Callaghan, 1819, p. 528–33), we are told in reference to the north bank of the Mohawk, of a "high road (from the west) which is passable for carts for 12 leagues to Col. Johnson's Mansion." Within this distance, which was really about 30 miles, were 500 houses, those on the river being mostly of stone. This points to the exposed limestones and abundant loose slabs of thin rock along the Mohawk zone. The people were said to be Germans (Palatines) and there was, as we have already seen, a mill near Johnson's house (Fort Johnson). There was a "good road" from this point to Schenectady. "All kinds of vehicles pass over it." Here the people were Dutch. We leave the reader to imagine just how "good" this road was.

The road south of the river west of Fort Hunter is called "pretty good," for "carriages pass over it." The road continues to Schenectady and here also the people were Dutch.

We here reproduce from the documentary history a section of Southier's map of the province of New York in 1779 (fig. 10).


Figure 10 From map of New York in 1779, dedicated to General William Tryon.

We include territory for several miles outside of the four quadrangles, the better to show the relations of the streams and of such roads and settlements as then existed. On the west we include the mouth of Caroga creek and on the east Schenectady and Long (Ballston) lake. Northward we take in the headwaters of the Sacandaga river and its junction with the Hudson. Southward a section of the middle Schoharie valley is included and the highlands of the Berne and Schoharie quadrangles.

Amsterdam has not appeared and there is no settlement as yet by the mouth of the Chuctenunda creek. South of the river was the now defunct settlement of Warrensborough. Fort Johnson is on the map, also Fort Hunter and to the westward is Caughnawaga. It is too early for Fonda. Johnstown, Kingsborough and Mayfield are present, but not Gloversville, or Fonda's Bush. Duanesburgh appears in the southeast.

We find the roads extending continuously west of Schenectady on both sides of the river. There is a road from Fort Hunter south over the hills east of Schoharie creek and from the Mohawk, where Sprakers now is, southeast over the hills (by the present Rural Grove) to the Schoharie valley. Another road runs from Schenectady to the Schoharie valley along Norman kill. On the north a road led from Fort Johnson to the Sacandaga river, joined at Johnstown by a road from Caughnawaga. Caughnawaga and Johnstown were joined to Stone Arabia. On the map Auriesville is Aries Kill and the northern nose is Anthony Nose.

The north shore road was known as the "King's Highway." Referring to this and the other roads in 1775, a competent authority says, "Without exception they were bad, leading as they did over high hills to avoid swamps and passing through dense forests. They were either filled with boulders or were sloughs of mud" (Frey, S. L., '05, p. 139, 140).

In 1792 conditions must have been better, at least a traveler toward Niagara in that year did not find the roads so bad as to divert him from the landscape. He saw a transformation from the wreck of war—"every house and barn rebuilt, the pastures crowded with cattle and sheep and the lap of Ceres full. Most of the land on each side of the Mohawk river is a rich flat highly cultivated with every species of grain, the land on each side the flats rising in agreeable slopes." The river completed the picture and gave the traveler the "most pleasing sensations imaginable" (O'Callaghan, '49, p. 1105).

## First Improved Roads

The Mohawk Turnpike Company was formed in 1800 to improve the travel which was created by the opening of western New York and the regions beyond. The Lancaster turnpike, leading out of Philadelphia, had been completed in 1794, and an area of road building opened in which the Federal Government, the states and private capital cooperated. DeWitt Clinton, as late as 1810, pronounced the condition of the Mohawk turnpike "inexcusably bad," in view of the plentiful supplies of stone and gravel which were near the road. But there was improvement and United States mail lines covered the 300 miles between Albany and Buffalo in 72 hours and canvas-covered freight wagons passed through Amsterdam and Fonda, each drawn by four to eight horses and corresponding, in that time, to the freight trains of the New York Central Railway today.

From 10 to 14 miles south of the Mohawk, through the valleys and over the high ground of the south end of our area, ran the Great Western turnpike, later known and still known as the Cherry valley turnpike. Charters for various sections of this road date from 1799 and succeeding years, the date given belonging to that part of the road with which we are concerned. The road crosses the Amsterdam and Fonda quadrangles by way of Norman kill valley, Duanesburg, Esperance, Sloansville and Carlisle. It is very direct, crossing hill and valley, after the fashion of early roads whose engineers sought to avoid the widespreading swamps of the forested lowlands. This road was thronged with the private vehicles, coaches and freight wagons which were characteristic of the period, and by droves of swine and herds of cattle driven to market. After 1825 the Erie canal diverted some traffic from the turnpike and in the decades that followed, the railways took all the through traffic and the turnpike became for 40 years or more a country road, silent and in parts almost deserted. Its revival as a trunk line for automobile traffic will be noticed later.

Our region had its share in the development of the plank road, which met the conservative prejudice against railroads and raised vehicles effectively out of the mud. Thick planks were laid on sills, and the earth wings were graded and drained. In the 20 years following 1835 there were built in the State of New York 2000 miles of plank road.

One of these roads, built by different companies, offered continuous traffic in 1849 and thereafter from Fultonville and Fonda

on the Mohawk, to Johnstown and Gloversville. The trail, the mud road, the improved earth road and the plank road were leading to the transportation of today. In 1849 also a plank road was completed from Amsterdam to Broadalbin and from Broadalbin to Fish House on the Sacandaga river.

### Fords, Ferries and Bridges

The Mohawk and Sacandaga rivers and Schoharie creek are all subject to flood currents of great volume. The Sacandaga is fed by the Adirondacks, the Schoharie by the Catskills and the Mohawk by both highlands, with additional water from the plateaus of central New York.

The only fording place mapped as such on the topographic map within our area is on the Schoharie creek. It is barely two miles up the stream from the bridge leading across the creek from Fort Hunter. Likewise but one ferry is in operation in our field of study, and this at Hoffman has been long in operation, having been established in 1790. Here on each side of the river were a tributary stream, a small hamlet and at length a railway station, requiring passage of the river—a traffic that would pay, but would not pay for a bridge. Here for almost 140 years successive owners have maintained a small barge and when flood and ice did not forbid, have carried man, beast and machine.

Five bridges cross the Mohawk river in our area. The most westerly joins Fonda and Fultonville and the first bridge at this point was built in 1811. Here was an important connection with the growing leather and glove interests of Fulton county, especially after the opening of the Erie canal in 1825. Lumber was brought here from the northern forests, and here hides and leather were sent to Johnstown and Gloversville, to be returned as a finished product and distributed east and west.

The next bridge joins Fort Hunter and Tribes Hill, the only suspension bridge, so far as the writer knows, along the course of the Mohawk. Crossing at Amsterdam was for many years by ferry, the first bridge being built in 1821, in time for the traffic of the Erie canal which began to center at Port Jackson four years later. The remaining road bridge belongs with a dam of the Barge canal at Rotterdam Junction, and yet lower down the Fitchburg Railway crosses the Mohawk to its junction with the West Shore Railway.

Schoharie creek has had many bridges. A "substantial" bridge is said to have been built over Schoharie creek at Fort Hunter as

early as 1796. At one time there was a bridge, no longer in existence, at Mill Point. There are two bridges between Mill Point and Burtonsville and there is one at Burtonsville, whose earliest predecessor was carried across Schoharie creek in 1790.

Four of the old covered bridges in our field, built of timber, have survived until the present time. One of these, crossing the Schoharie at Esperance, is giving way to a modern bridge adequate to the revived Cherry valley turnpike. The others stand across the Sacandaga river at Osborn Bridge (fig. 68), at Northampton (the ancient Fish House), and joining Edinburg and Batchellerville. All these must soon be removed, when the river is lost in the new Sacandaga reservoir. Apparently the ferry will become an essential means of transport in that region.

## Transportation by Water

The Mohawk river was a highway from Indian days. In early federal times it was vastly important, but its use has declined to a minimum, while land transportation has steadily grown and was never so great as now.

The birch bark and dugout canoes were the first craft, propelled by oars and pulled over the rifts. In our section two of these obstructed bits of navigation were found, the Fort Hunter rift and the Caughnawaga rift. The white man had greater needs and moved his household goods or the produce of the soil in batteaux, larger boats, paddled, poled or towed and carrying much heavier cargoes than the primitive craft. Then came in the Durham boat, much larger, 40 to 50 feet long, and carrying many tons.

The use of larger boats was made possible by the work of the Inland Lock and Navigation Company in the last decade of the eighteenth century. Wing dams were built at the rifts to concentrate the river's flow, and the canals at Little Falls and the Oneida Carrying Place were constructed. Sails were used when possible and 18 to 25 miles a day were attained.

Schenectady was a center for the making, equipment, departure and arrival of these boats and not only furniture and farm products but furs in quantity and passengers were carried. The year 1812 saw the passage of approximately 300 boats on their way to the Oneida Carrying Place (now Rome).

The only competitor of the river route in these years was the turnpike, which, as we have seen, was gradually improved and could make transit more speedy along the Mohawk valley flood plains and over the Cherry valley turnpike.

In 1825 the water resumed its supremacy, not now by river, but by the Erie canal on its south bank. It is no part of our plan even to sketch the history of this great waterway, but rather to place it serially in its relation to the earlier and later carriage by land and water. On its waters cargoes large for the time could be carried during the open season, and packet boats offered safe and comfortable journeys to Utica, Syracuse and Buffalo. Both the speed and the conveniences are to be judged not by present standards but by those of one hundred years ago.

During the first season of the open canal in 1825, 42 tow boats of various types passed through Utica by average reckoning for each day. We give this available figure that the reader may picture the traffic which must have passed Fultonsville, Fort Hunter, Port Jackson and Pattersonville during every day of that summer. The canal was absorbing traffic from the roads, and the opening of the railway from Schenectady to Utica was then 11 years in the future. The canal was the outlet and inlet for western New York and the developing central states. The writer remembers the mountains of apple barrels on Genesee canal docks in October, many years after the railways carried heavy traffic. Many of these apples must have gone through the eastern stretches of the canal on their way to the seaboard. Gradually in the later decades of the last century the Erie canal became a lonely and almost abandoned waterway.

The construction and the problems of the Barge canal also are foreign to our present purpose. It is the latest stage of waterway development in the Mohawk valley and its future is unknown. Its locks and dams are seen at four points in our area—Rotterdam Junction (fig. 69), Cranesville, at Guy Park in Amsterdam and at Fort Hunter.

The Sacandaga river until recent years was an important avenue for the transport of logs. They were caught in a boom at Northampton and sent down the lower river in time of flood. It is not expected that log driving will ever be renewed on the river. At one time boats of light draft plied the river from Northampton to Conklingville and in the time of the Revolution the people of Edinburg put a heavy chain across the river to prevent a possible ascent of its waters by a hostile force.

## The Railways

In 1836 it was recorded as a marvelous experience that one could take breakfast in Schenectady, dine in Utica and have tea in Albany, traveling nearly 200 miles in a single day. This was made possible

on August the first of that year, by the opening to public use of the Utica and Schenectady Railroad, for which a charter had been granted in 1833. It was an extension across our area of the railway facilities that were afforded between Albany and Schenectady.

It does not appear that in 1836 the railway was expected to displace the Erie canal, for no provision was at first made for carrying freight by rail. When navigation stopped in the first autumn, a German at Palatine Bridge was permitted to convey his household goods to Schenectady on a car, and thus began the evolution of a public carrier which in fifty years practically left the canal without business.

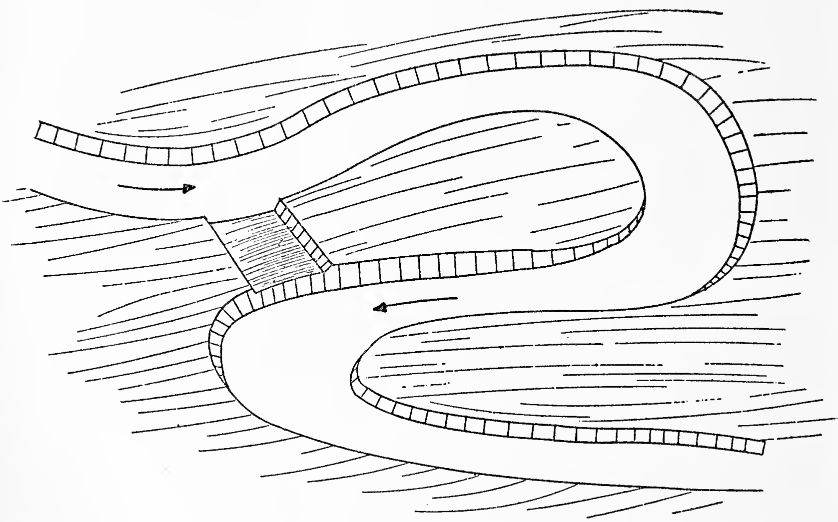

Figure 11 Meander of the Sacandaga river two miles south of Batchellerville. Shows attempt to cut off meander, to facilitate log driving.

Soon after 1880 the West Shore Railway was built as a rival to the Central Lines. After a severe race in rate cutting the newer road was absorbed by the older, and the way opened for a single management of the six tracks that now border the Mohawk river. The Utica and Schenectady road had become a part of the consolidated line across the State in 1853.

The Boston and Maine Railway (Fitchburg) extends about three miles into our region, crossing the Mohawk river at Rotterdam Junction and connecting with the West Shore Railway.

The Delaware and Hudson Railway loops over the southern border of the Amsterdam quadrangle for a little over two miles near the

village of Duanesburg, and there is joined by the Schenectady division of the same railway. The junction is two miles west of Duanesburg and the line follows the natural route through Norman kill valley, leaving our area at South Schenectady.

Railway communication north of the Mohawk river was long delayed. The Fonda, Johnstown and Gloversville Railroad Company dates in organization from 1867 and the line was opened in 1870. In 1872 a company was organized to build a road from Gloversville to Northville, and service began in 1875. A branch line was constructed to connect with Broadalbin. We have now noted all the steam railways in our area.

Electric lines now serve the lower Mohawk valley and the Fulton county cities. From Schenectady the north bank of the Mohawk is followed through Hoffman and Amsterdam to Tribes Hill. Thence the line bears northward to the glove cities, and runs from Johnstown to Fonda. There has long been local and suburban street railway service in Amsterdam, Johnstown and Gloversville. An electric railway reached Mountain lake from Gloversville but has been abandoned, doubtlessly one of the changes due to the motor car and the improved road.

### The Modern Roads

The new mode of transport is by motor car, and the concomitant of the motor is surfaced roads. In earlier days the canal replaced in large measure the turnpike and was in turn left aside by the railway. No such substitution is now in progress. The motor car takes some traffic from the railway but adds much to it because it widens the reach of the railway line. This is true in our area, where a considerable number of villages and thousands of rural homes are many miles from a railway. Most of these villages and homes are now on or near good roads, and use them by means of mechanical energy. In the future we shall see man's movements in a manifold and harmonious adjustment in the various forms of land, water and aerial carriage.

The surfaced road offers three trunk routes across our area between east and west. The first to be named is the Mohawk turnpike on the north bank of the river with its subsidiary line, less advanced in modern construction, on the south side of the Mohawk. The second route is by the Cherry valley turnpike, the Great Western road of a hundred years ago, recently improved throughout and opened to modern traffic. It is the shortest roadway between Albany and Syracuse and has no centers of population except hamlets and villages of modest size. Considering its altitudes in our district and westward, its grades are moderate and it is suited to through travel.

The third trunk highway is north of the Mohawk river. Like the Cherry valley and Mohawk roads it had an early beginning. Early in the last century the Legislature authorized a road leading westward from Johnstown toward the Black river country along the southern border of the Adirondacks. It was much used by immigrants in the settlement of northern New York. From Johnstown


*Courtesy General Drafting Co.*

Figure 12 Map showing modern highways.

going west it passes through Cork, Caroga, Lassellsville, Dolgeville and Salisbury to Middleville and thence to the northwest. Eastward it completes the crossing of our area, through Broadalbin and Mosherville and passes on to Saratoga Springs, a finished roadway following the trail over which friendly red men bore Sir William Johnson to the mineral waters of Saratoga.

Good roads now lead across the hills between the Mohawk and the Cherry valley turnpike. One may go from Fultonville by way of Glen and Charleston to Sloansville, or from Amsterdam by Minaville to Duanesburg, or through Mariaville to Schenectady. The old trail and early road from Sprakers to the Schoharie may be followed on a hard road as far as Rural Grove.

To the north we find the road from Fonda, by Johnstown, Gloversville and Mayfield to Northville and the upper Sacandaga. We may also go from Amsterdam by Perth and Broadalbin to Northampton, along the course of the mid-century plank road. Reaching up from Schenectady is a superb road to West Charlton, soon to be carried through Galway to an intersection with the Johnstown and Saratoga highway. Hard roads run from Gloversville northwestward to the nearer Adirondack places of resort. Our map (fig. 12) shows the present state of these roads. So swift is the unfolding of modern transportation that the map of today will show the incomplete road-net of tomorrow. Everywhere the keen sense of the red man or the convenience of the pioneer reveals itself in the roadways of our own time.

## The Rise of Industries

To give a history and description of the leading sorts of manufacture would require extended treatment. We only can ask what causal relations, if any, the resources of the region have sustained to its industries.

The center of the most varied production is the city of Amsterdam. The Chuctenunda creek is a strong and unfailing stream, having nearly 600 feet of fall between the reservoir in Galway and the Mohawk river. Of this fall 350 feet are concentrated in the three miles from Hagaman to the river level at Amsterdam. Through the city it is more like a water slide than an ordinary rapid. Mills are thickly set upon it (fig. 72).

This stream was an early incentive to manufacture. In 1802 there were five mills on the stream; in 1813 there were 17, including five grain and four sawmills, four carding and fulling machines, two oil mills, a triphammer, and an iron foundry.

Large special enterprises began to develop after 1840. Of these we name four classes of manufacture, although there are many others. There are several knitting mills. If we seek explanation from environment, the water power is sufficient for beginnings but not for continuance on a large scale. It may be added that in the Mohawk valley, Cohoes, Little Falls, Utica and Amsterdam form a zone of knit goods production. Carpets are an immense industry

in Amsterdam. Their making began in a small way in Hagaman and shifted to Amsterdam through the acquaintance of the first maker with a Scotch dyer whose father made ingrain carpets in his native land. Aside from the small water power the initiative and the development have been purely human.

The ancestor of the present proprietor of the linseed oil works began his business in West Galway. Later he found water power in Amsterdam, and, like all the other industries, favorable transportation of raw materials and finished product. Brooms are another element of Amsterdam industry. The flood plain of the Mohawk west of Schenectady once bore much broom corn. None is there today, but the industry has persisted.

Here we have the controlling principle. Human initiative, developed capital, technical skill, a supply of trained labor, reputation of the product, experience in marketing—all these make an industry persist from an early start and may develop it far beyond the capacity of the physical environment to supply either raw materials or power. That natural factors were not neglected is shown by the construction in Galway in 1860 of a reservoir to conserve and control the flow of Chuctenunda waters. This was enlarged in 1876 and now adds beauty to the hills and power to the city.

Gloversville and Johnstown, the double glove centers, are very different from Amsterdam. The glove-making of Fulton county depended not at all upon power and very little upon local raw materials. Almost from the beginning it searched America and all the world for its hides and skins. There are no other enterprises of comparable magnitude in the glove center. Amsterdam has recently acquired in addition to its dominant old stock, a large percentage of foreign people. Gloversville on the other hand has only 14 per cent of foreign born.

The manufactures of the leading Amsterdam products are concentrated in a few large mills, run by machinery. Glove establishments are numerous and many of them small. This is possible, for most of the work is hand craft. This is also illustrated in the diffusion of the industry through Fulton county, with factories in Mayfield and Northville and with sewing machines and industrious women in hundreds of homes on farms and in villages, making up the gloves that have been cut in the factories of the twin cities.

We have no space for dates or names in the origin of the glove industry. The initiative was wholly human. Available deer skins and hemlock bark may have had some slight effect, but were not essential either in the origin or growth of the business. All the

world is tributary in raw materials and the markets are wide. For long the business was ten miles from a railway. It could be so because freights were relatively small as well as the power requirements.

There is no geographic reason why the glove industry should have grown large or should now continue at the foot of the Adirondack slopes, unless it be that clear air and good drainage, lake and forest make life there desirable. But there has been every human reason why the business should begin, grow and stay. Our conclusion is that the geographer can find enough interesting relations between nature and man, without making exaggerated claims in the field of geographic influence.

## Power Development and Transmission

A notable example of changes by man in our field is found in the Sacandaga reservoir, a project of the State of New York which is far advanced in surveys and in financing. The new body of water is one of several to be created on Adirondack streams for the development of power, the preservation of regular flow for industries and hydroelectric plants and the prevention of destructive floods.

We find special interest in the new development because in creating the reservoir the hand of man will approximately restore the body of water which we have described as the glacial Lake Sacandaga. The reader will remember that this lake developed as the Sacandaga glacier front receded northward. It was held in place by ice blockading the Sacandaga valley from Edinburg and Batchellerville and northward, and it had its outlet past Vail Mills and over the col at the head of Skinner creek (fig. 28). By the removal of the ice dam, the lake was drained along the new course of the Sacandaga river over the preglacial col at Conklingville, leaving exposed the Sacandaga delta (figs. 39 and 40), also the marshes known as the Vly in the towns of Broadalbin, Northampton and Mayfield. The new work is carried on by the State through the Board of Hudson River Regulating District, having its office in Albany.

The reader will best understand the description now to be given, by referring to the map (fig. 15) on which are outlined the shores of the new reservoir. The boundary line has been somewhat generalized from the larger map published by the regulating board. Our map shows the lake to the boundary of our area but does not exhibit its lower extension in Stony Creek and Luzerne quadrangles to the village of Conklingville where the dam is to be built.

The reservoir will have a capacity of 283,000,000,000 gallons. The surface of the water may be held at altitudes of 740, 756 or 771 feet, with the consequent water area varying from 16,300 acres to 26,700 acres. The area of the lands to be acquired is about 29,000 acres. The top of the dam is to be 795 feet above mean sea level. The approximate length of the reservoir is 27 miles, and its greatest width, at Northampton, is somewhat over five miles. The shore line will be 125 miles long.

The dam at Conklingville will be 1200 feet long, 115 feet in maximum height, 600 feet thick at the base and 40 feet at the top. Much of the lake will be shallow, the deepest waters being along the present course of the Sacandaga river. At Sacandaga Park the depth is 32 feet, the depth gradually increasing to 50 feet at Fish House or Northampton. From that point to Conklingville 50 feet is an average of the deeper parts. The new lake will compare in size with Lake George and will have more capacity than the Ashokan and Gilboa reservoirs combined.

Striking changes must be made in man's relation to the submerged area. A very small part of Northville will be occupied, and parts or all of a dozen small villages. Those that will be entirely wiped out are Osborn Bridge in our area, and Day and West Day, north of our boundary, toward Conklingville. Villages to be partially destroyed in our area are Batchellerville, Edinburg, Northampton, Benedict, Munsonville, Mayfield and Sacandaga Park. Only a very small part of Mayfield will be affected. Including the farm population about 1100 people must abandon the area.

Other changes include the removal of 22 cemeteries and nearly 4000 reinterments, and the inundation of 68 miles of existing highways. New roads to be built include 20 miles of gravel roads, 20 miles of earth roads, and 5½ miles of paved roads. About 7 miles of the Fonda, Johnstown and Gloversville Railway between Mayfield and Cranberry Creek must be relocated, and more than one-half mile between Sacandaga Park and Northville. Ten highway bridges will be built, and three interesting relics of a past time will disappear in the destruction of the covered bridges at Osborn Bridge, Northampton and Batchellerville.

Looking again at the map outlining the lake, we observe that most of the old Sacandaga lake delta will be submerged. A small island (low till hills on the glacial map) will appear west of Osborn Bridge. A drumloid hill east of Munsonville will also stand out above the waters. Several narrow bays will be found southeastward from Mayfield, conforming in trend to the drumloid topography and

the direction of movement of the Sacandaga glacier in that region. The head of the lake north of Vail Mills is about two miles from the col where the glacial lake had its outlet. A small increase in the height of the dam at Conklingville would send the Sacandaga waters down the Cayudutta creek to enter the Mohawk river at Fonda. The difficulty of crossing the lake, with its 27 miles of length, is reduced in importance by the fact that forested mountain slopes largely flank the lake on the east and west, and the population of the separated region is therefore small. Apparently the residents of the great upland spur between the two limbs of the Sacandaga river must reach the open and populous region to the south by ferry or by a detour to the village of Northville. It is expected that the cost of the project will approach $10,000,000 and that the work will be completed by 1930.

We have referred to limited power developments along Chuctenunda creek and other small streams. It remains to observe that our region has a large share in the network of transmission lines and multifold service of the Mohawk Hudson Power Corporation System. In the map (fig. 13) we include the greater part of eastern and eastern central New York, from Rome to the New England border. Thus can be seen the relation of transmission lines to our region, which, from west to east, lies between Ephratah and Schenectady.

The trunk line is not on, but is roughly parallel to, the Mohawk river. Focal points for hydro-electric power are at Trenton Falls on the West Canada creek, Inghams and Dolgeville on the East Canada creek, and Spier Falls, Mechanicville and Cohoes on the Hudson river. The Sacandaga development is yet to come. All the larger centers of our four quadrangles are served by this system. One of the chief steam electric plants is near Amsterdam. Outside connections lead to Niagara, Black river and New England sources of power.

## Recent Changes in Rural Life

Remoteness as we now reckon it was not disturbing to the pioneer. There were in our region no cities and no large villages. Each hamlet and every farm was almost self-sufficient, and long journeys, save for the emigrant, were few. The Cherry valley turnpike for a generation was a scene of activity. Then for decades it became a country road. The writer saw one section of that road in 1907. Poor soil, poor crops, little farm machinery and neglected houses filled the view. In three hours, seeing short grass, a few oats, two hop fields and not much else, he drove 12 miles on the ancient turnpike, met

one team and was overtaken by no one. On a recent visit he looked out from a great hill, upon the road, which was full of speeding motor cars.

A hamlet, which shall be nameless, seemed in 1907 to have been built and forgotten. With the present paved road and noise of traffic, one could not, undisturbed, stop to ponder upon its weathered structures. Mariaville was not remote, but it was silent. Now and for a few years its houses have increased by scores and its waters are frequented by a throng of summer visitors. Cork and Mosherville in 1907 seemed quite out of the living world. Today they are on a trunk road from east to west. Except in the Adirondack region there is no point in our four quadrangles which is not easily accessible to a good road.

Burtonsville was settled at the close of the Revolution. For many years it was a place of activity, with woolen mill, nail factory, tannery, lumber mills and various lesser shops. An old resident told the writer that he had seen 15 teams waiting there to unload buckwheat, drawn from the high surfaces of thin, bleached soil which still bear that crop. The same informant said that he had seen pork drawn from a farm within four miles of Amsterdam, sold in Burtonsville and drawn back past the home of the seller to be sold in Amsterdam. Now there are 15 families in Burtonsville, with a wagon shop, blacksmith shop, garage and two stores. But there are a good road, telephones and nine radio sets. The little group has rejoined the world.

Then came railroads, concentration of populations, mass production in industries and the decline and isolation of rural life. Now long-distance transportation, a network of local good roads, the rural free delivery, the telephone, the radio and the motor car have brought the world to the rural citizen's door. Nowhere save in great cities have the inventions and tastes of man made more changes in landscape and life than a period of 150 years has seen in the lower Mohawk valley.

## Eras of Physical and Human Unfolding

The geographer and glacial geologist deal with today and yesterday. Beyond these brief durations the history of our region is in the rocks. We know man here for three or four hundred years. Back of the Mohawk and the pioneer some thousands, possibly many thousands of years of forest and unknown savage intervene since the final melting of the ice. Coleman ('26, p. 71) thinks 25,000, possibly 35,000, years may have passed since the retreat

began. The time since our region was ice-free would then be much less than either figure. The same authority places the total duration of the ice age at 600,000 to 700,000 years.

It is reasonable to think that the glacial winter in the Mohawk region lasted a thousand times as long as the period in which we have an actual record of man in the valley. Any geologist may be expected to believe that the rocks and their fossils record a prior duration from one hundred to one thousand times as long as that of the ice age. Beyond this is time which the rocks do not record.

The rocks of the Adirondacks were accumulated in marine waters, although now changed almost beyond recognition as sediments. There were vast intrusions of molten rock, there was cooling, crushing and mountain building. There were in our region or on the north of it heights of unknown form and altitude.

In all the millions of years that witnessed the deposition of the limestones, shales and sandstones that underlie most of the surface of our quadrangles, salt waters were there to receive the waste swept in from bordering lands, and in these waters lived the forms that abound as fossils in these rocks.

Since the uplift and mountain building which closed the Paleozoic Era, our region has for many million years been land. To that period of disturbance probably belong the uplifts of the Noses, Hoffman and Little Falls. We know with certainty that many and fierce earthquakes must have shaken eastern New York, and that then no Mohawk, or Hudson, or other of the great valleys of New York existed. There was prolonged and vast downwear of the region in Mesozoic time, followed by uplift and making of these great valleys in Tertiary time.

The all-covering ice as it gathered gradually by local storms and was dominated by a push from the north, found a Champlain, a Hudson and a Mohawk valley to invade. The Mohawk was a short stream heading at Little Falls. The Sacandaga flowed southward to the Mohawk. A residual soil had long formed the surface, made by decay of rocks in place. For millions of years forests had covered hill and vale and been the home of animal life.

All life was destroyed or pushed southward for a period of some hundreds of thousands of years. Then came release. The old or modified biological groups crept back, not as individuals but as kinds. Then forest and stream, hill and valley, mountain and plain made the landscape. This landscape, older than Egyptian or Babylonian records, had not much changed when the Iroquois or the Dutchman first looked out upon it. We imagine with some

essential truth how our region looked before the ice age and when the ice age was here. We can interpret rather clearly the forms and marks and materials left behind in its retreat. We can read letter by letter and line by line the story of man and the changes he has here made. We have rocks, seas, mountains, plains, uplifts, valleys, ice, in descending ratios of time. Man enters the field almost at the end, and does his work here, with ascending measures of interest. A virtual infinitude of time gives dignity to the brief span of man.

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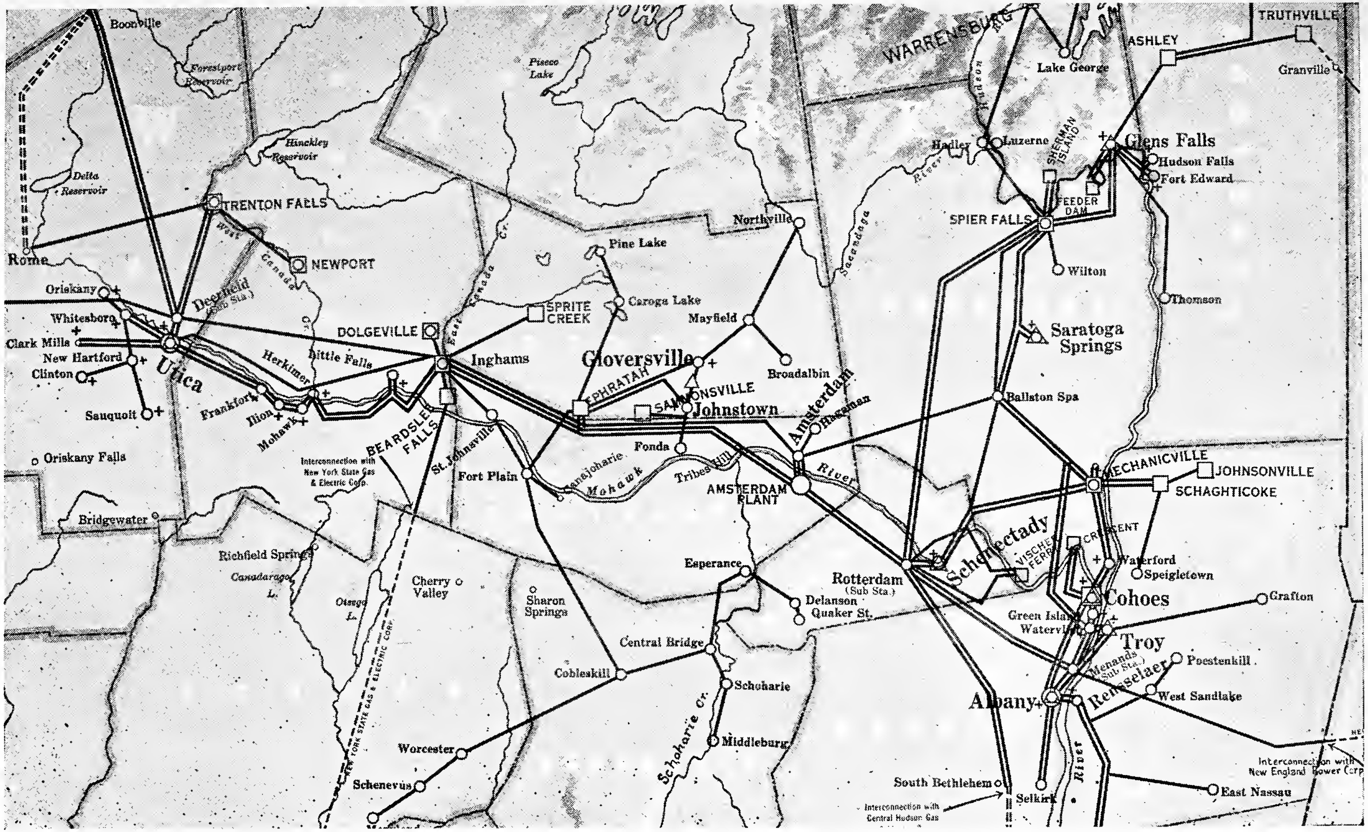


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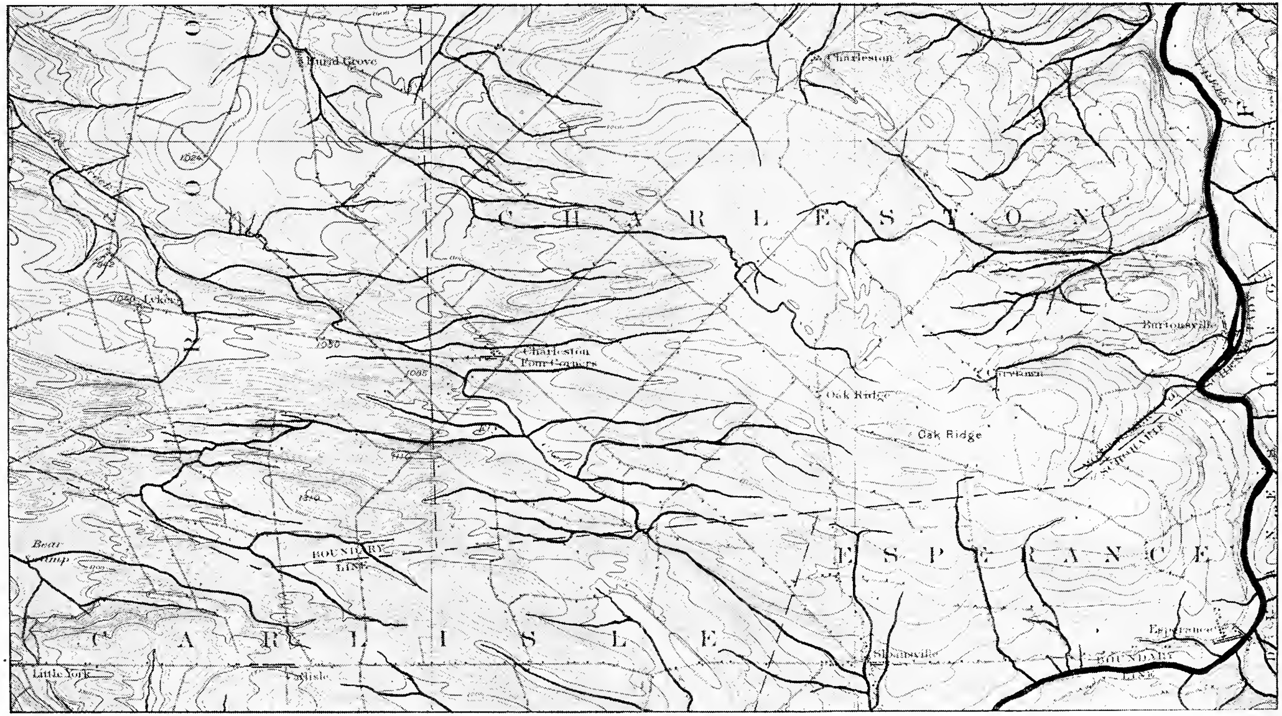


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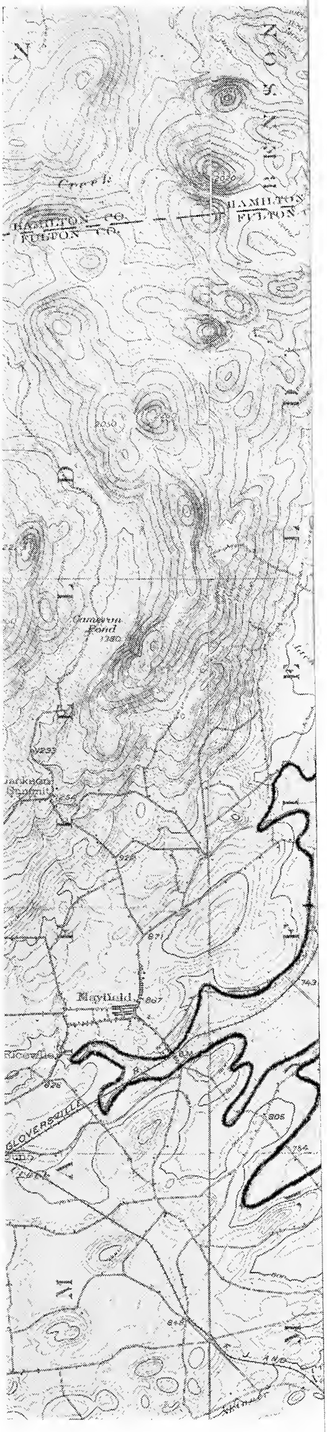
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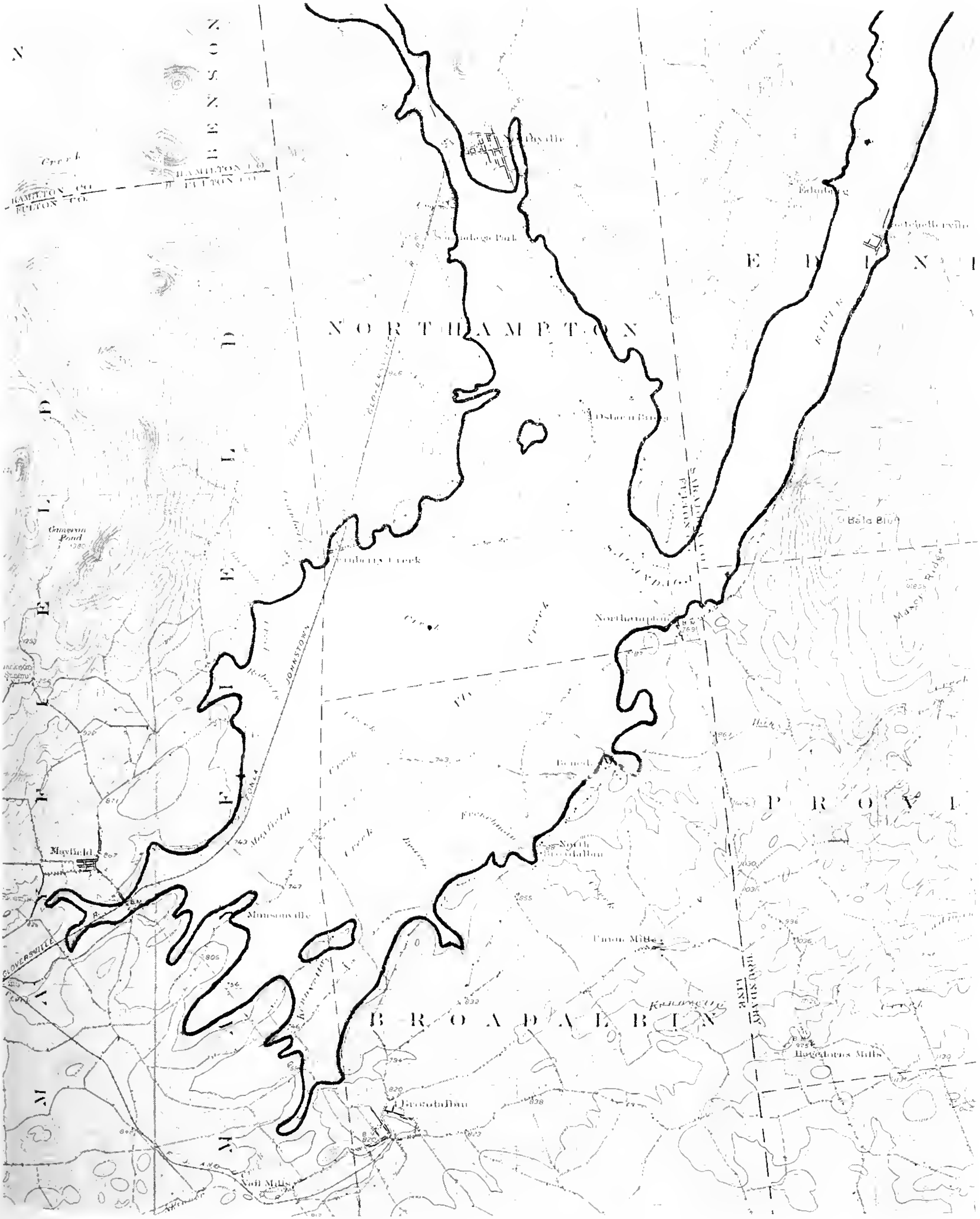


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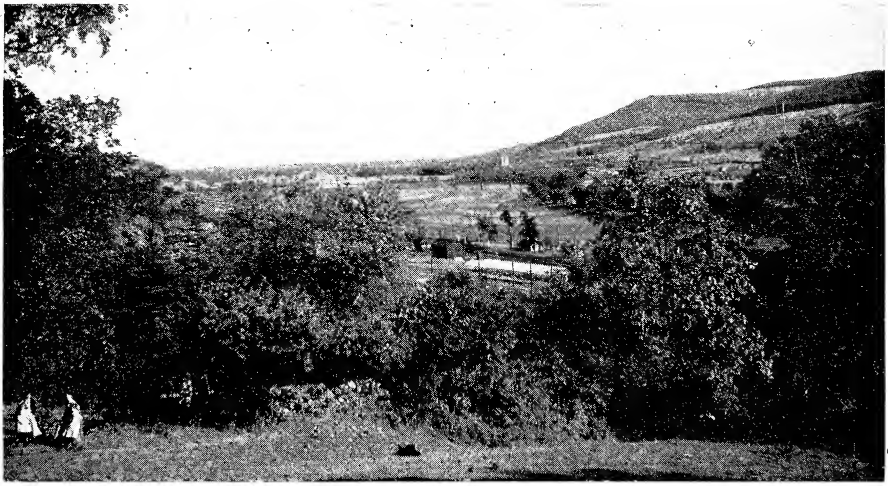

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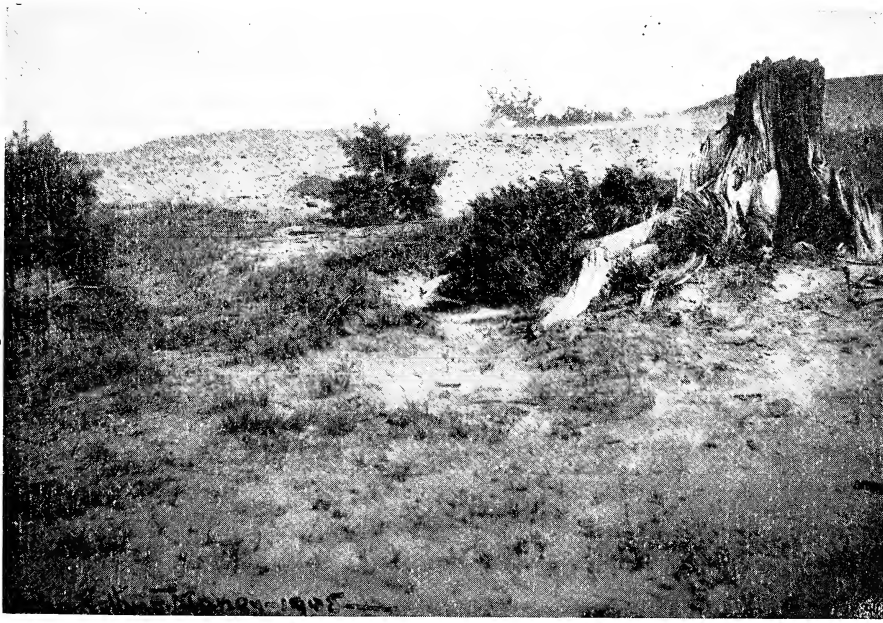

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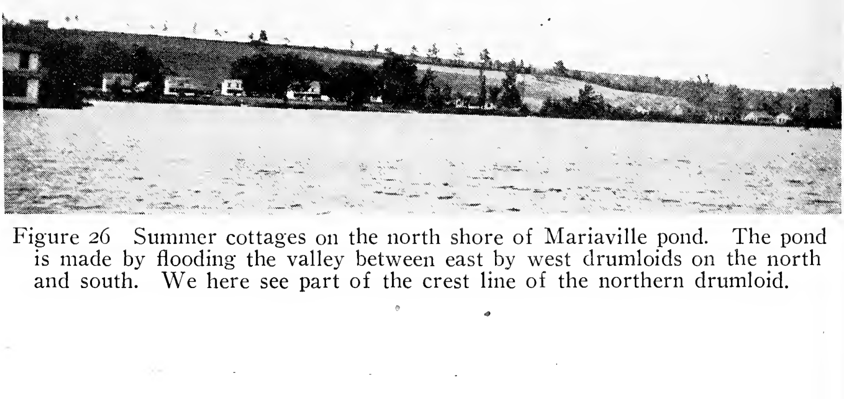

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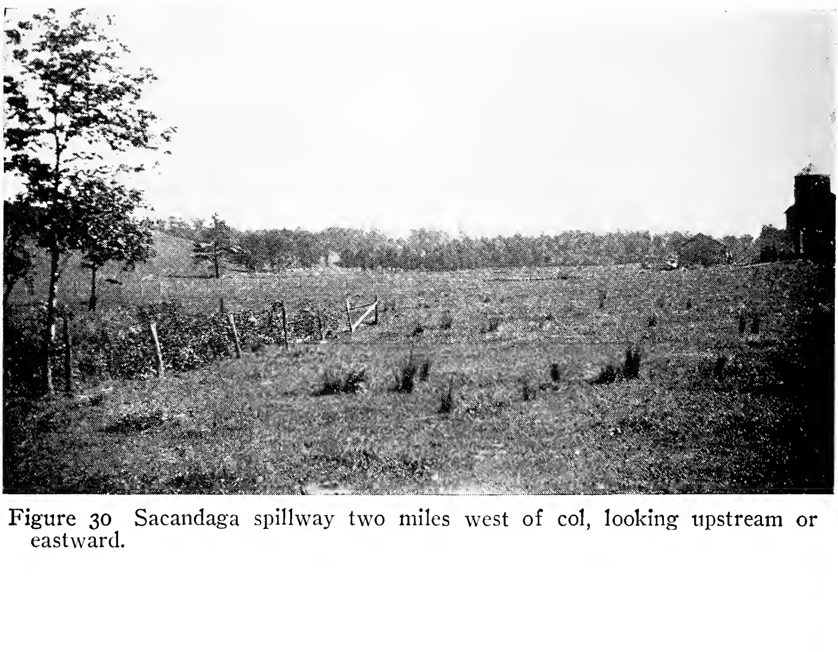

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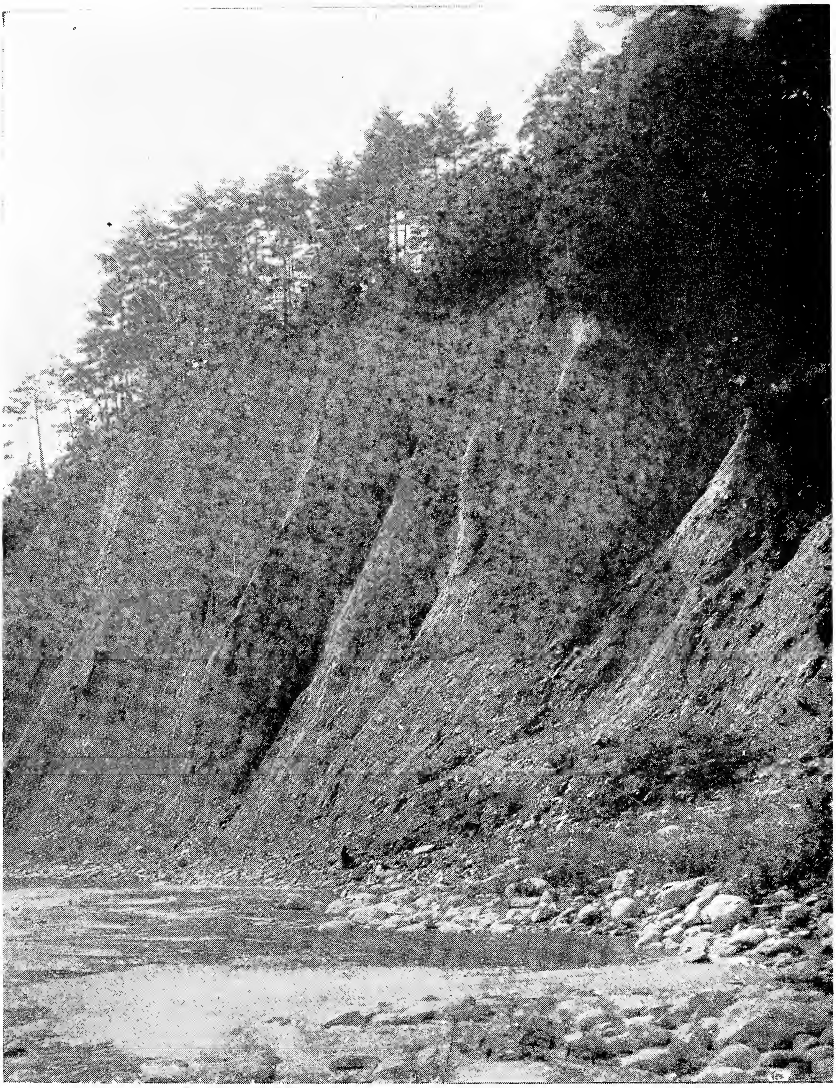

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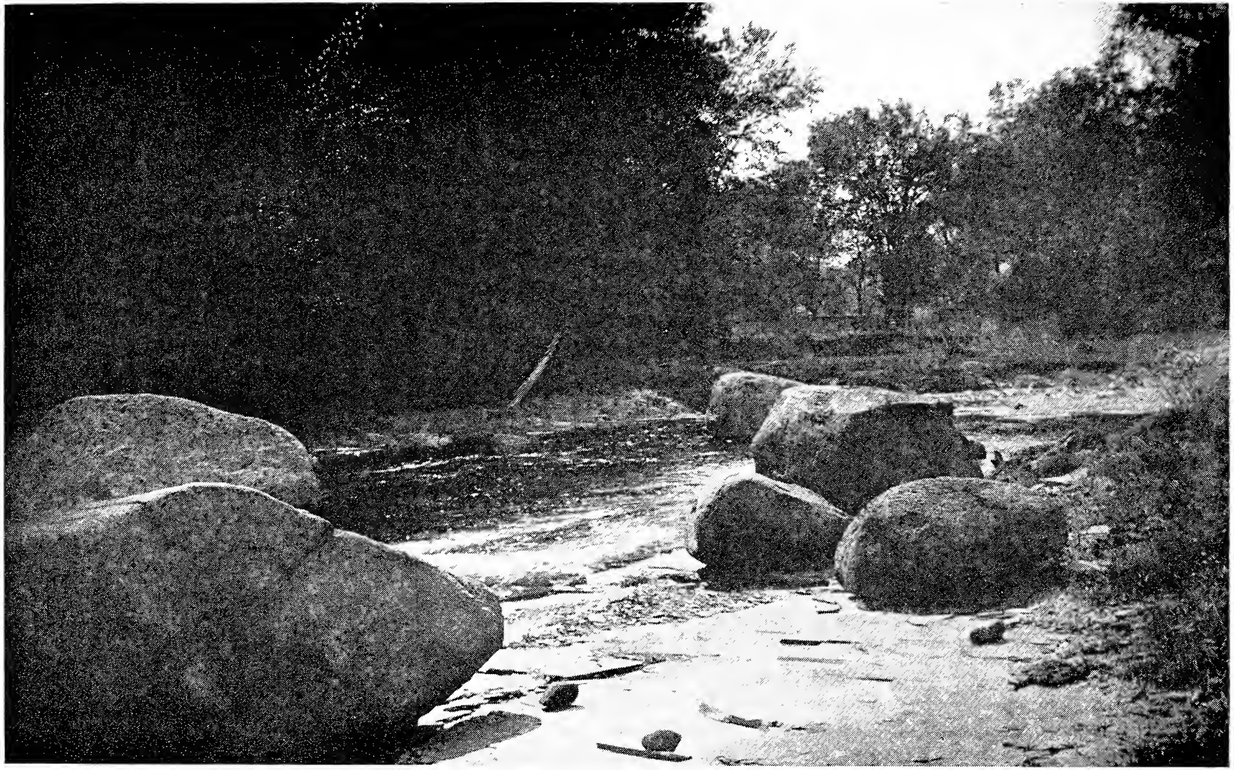

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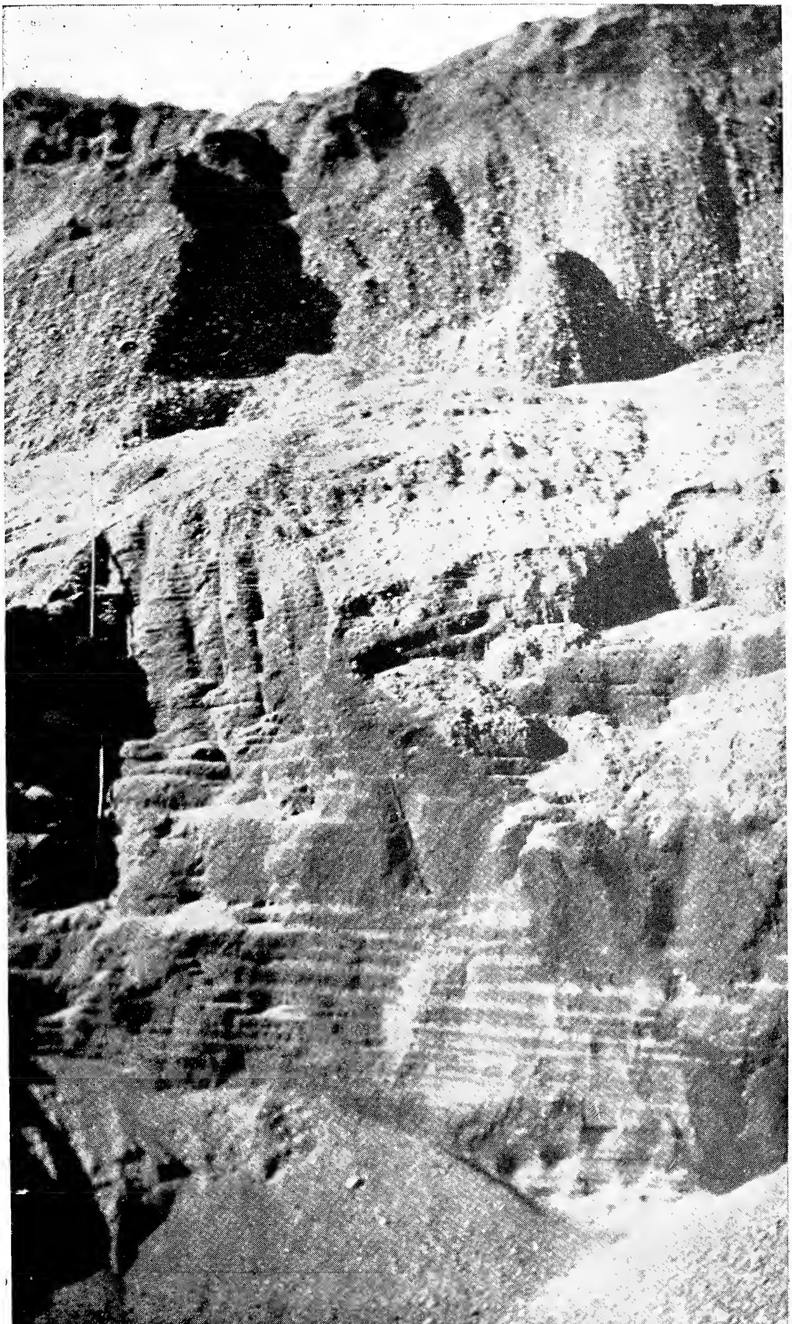

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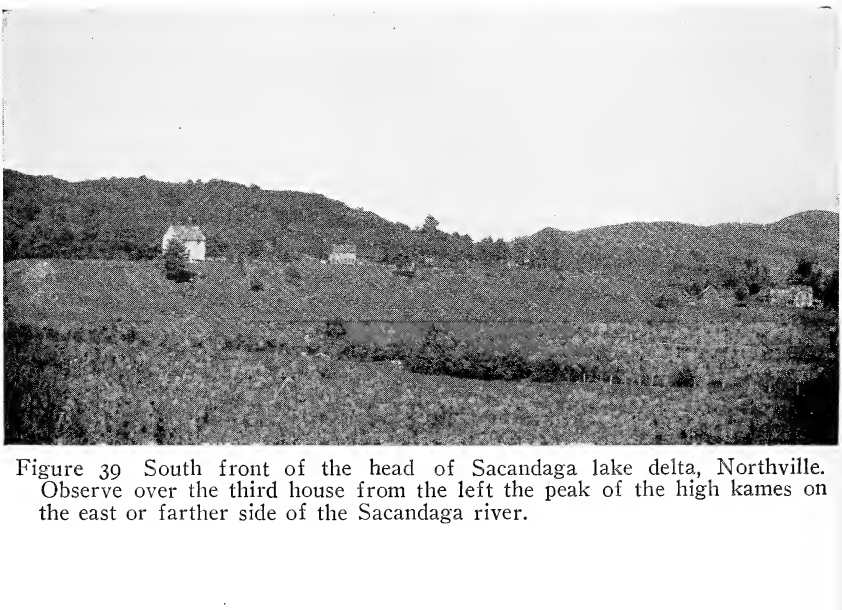

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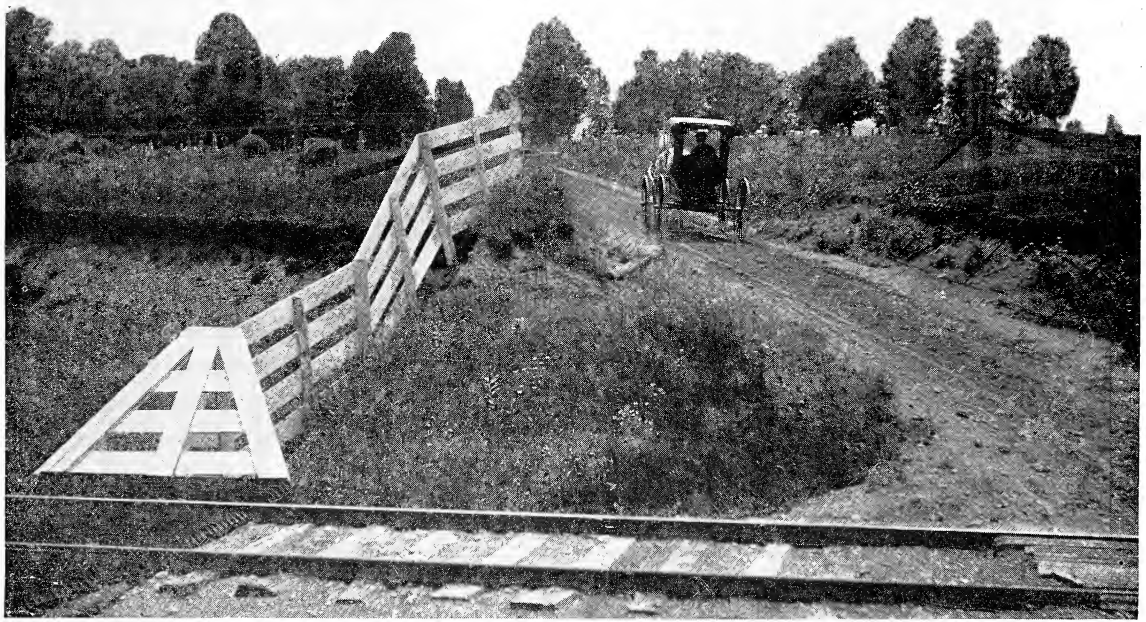

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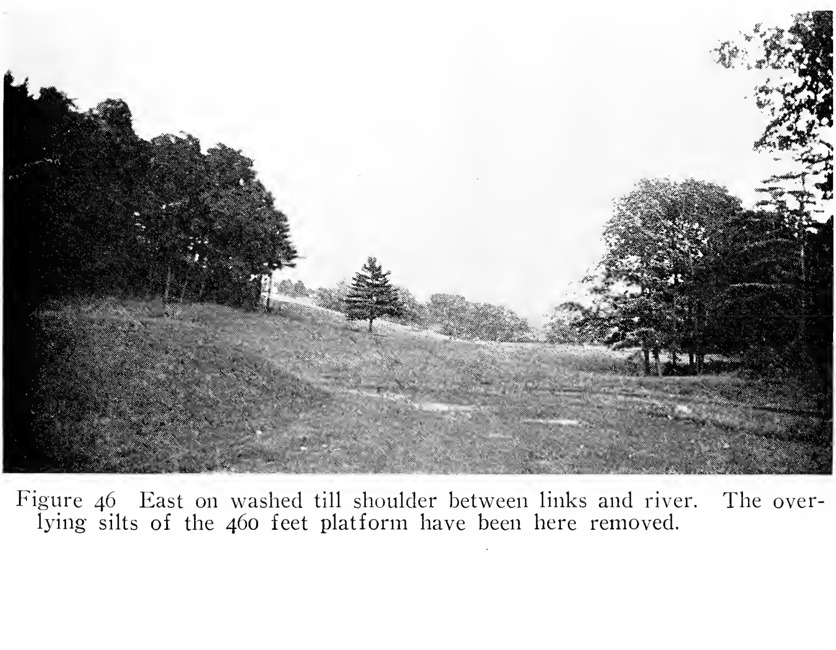

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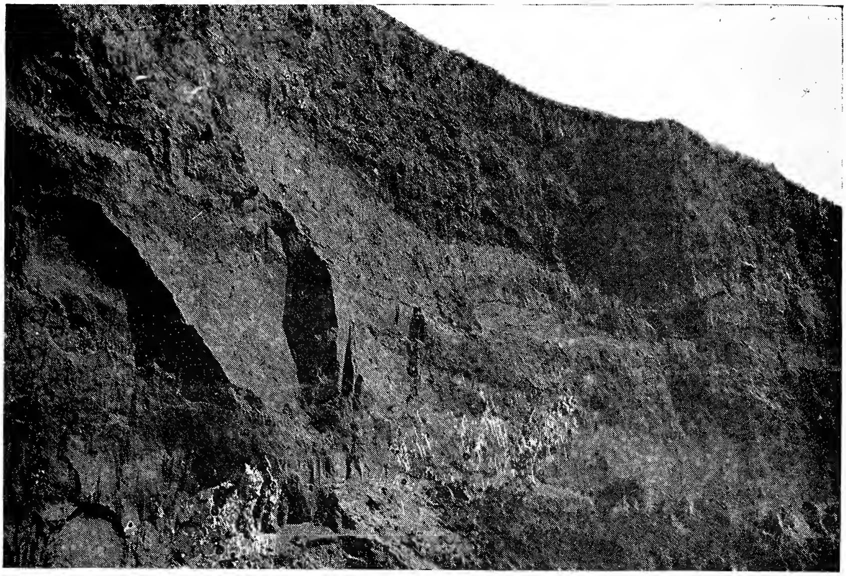

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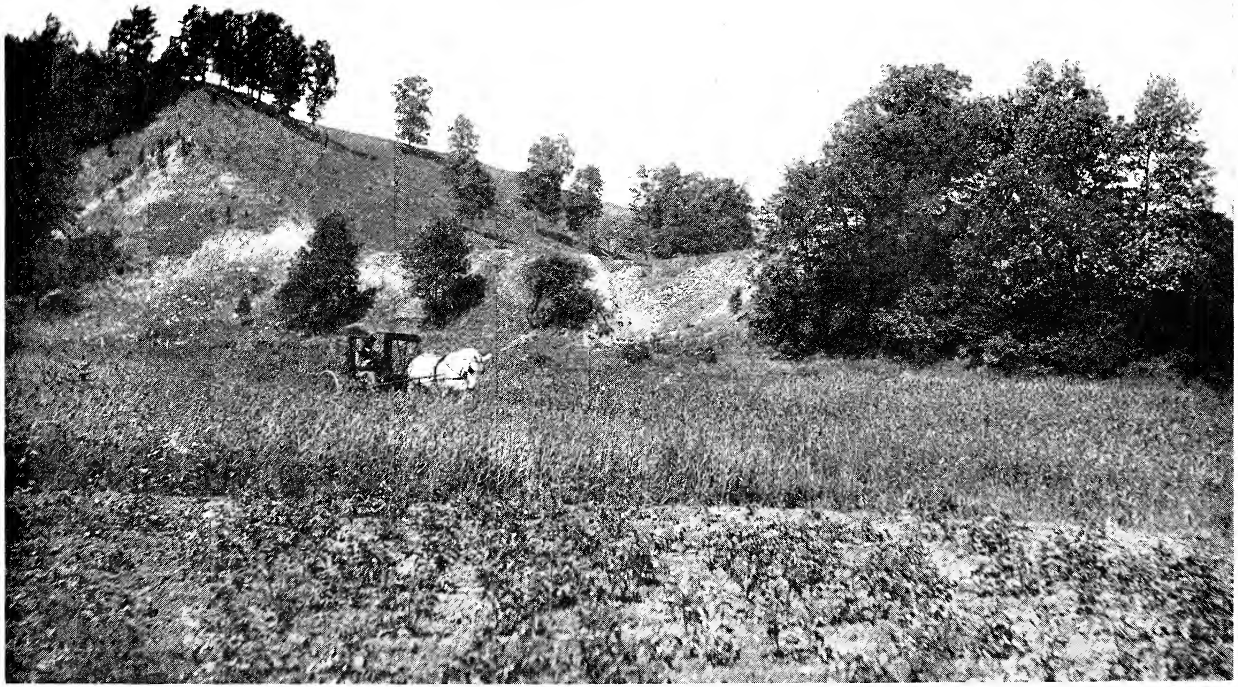


Figure 61 On farm of Jacob Newkirk, near Mill Point, from field of Henry Rutter. Looks across recent oxbow channel which undercuts the older and higher oxbow, showing north cliff of the older. Photograph by J. Arthur Maney.

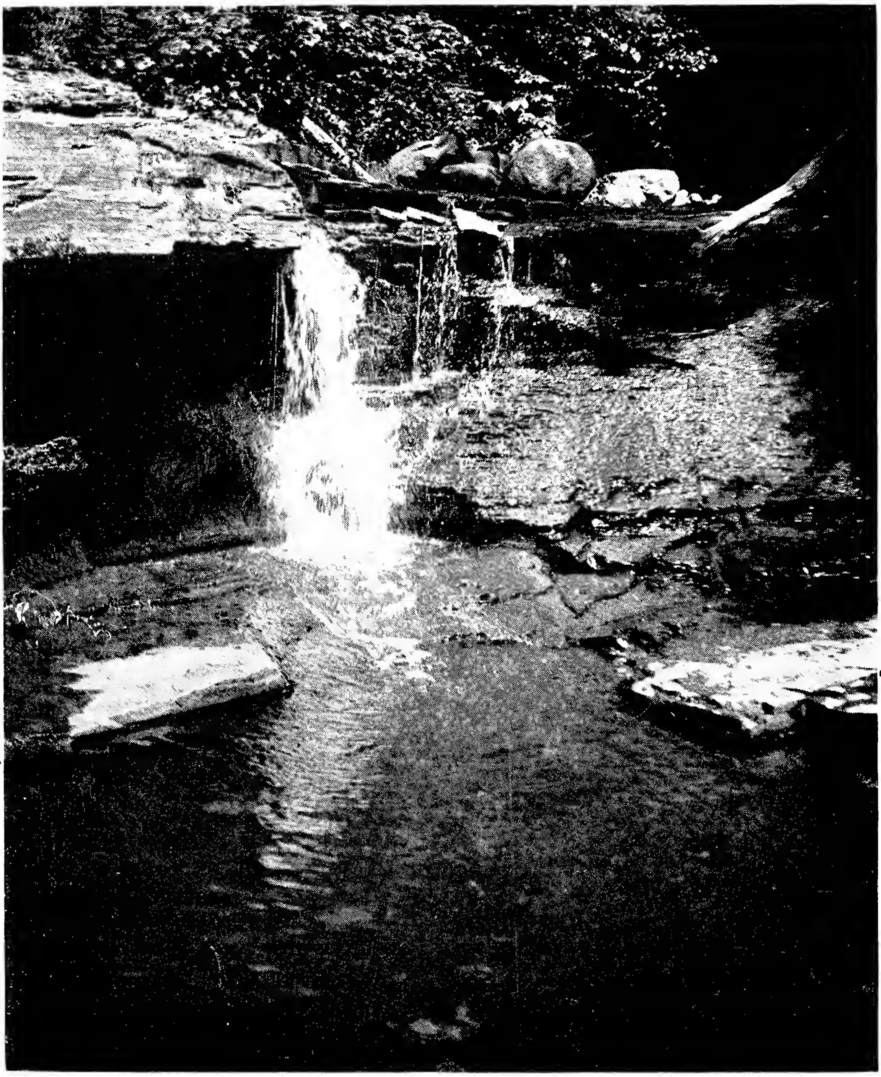
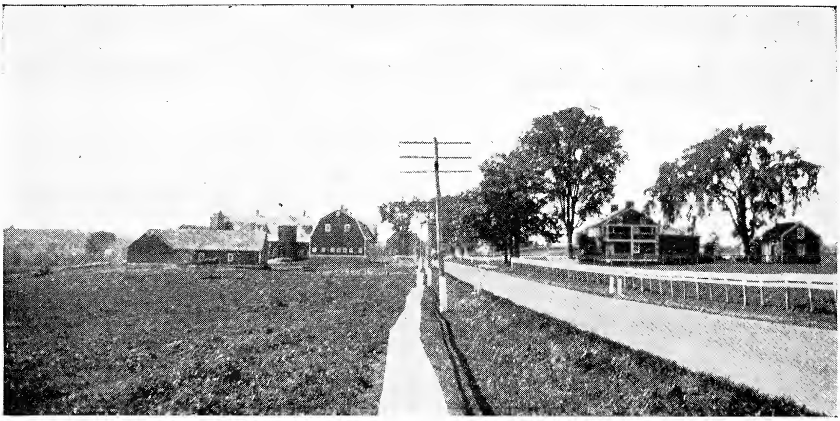


Figure 62 "Tequatsera" near Johnson's Station, nine-mile bridge below Hoffman. Glacial boulder above the fall, washed from the till. Photograph by J. Arthur Maney.



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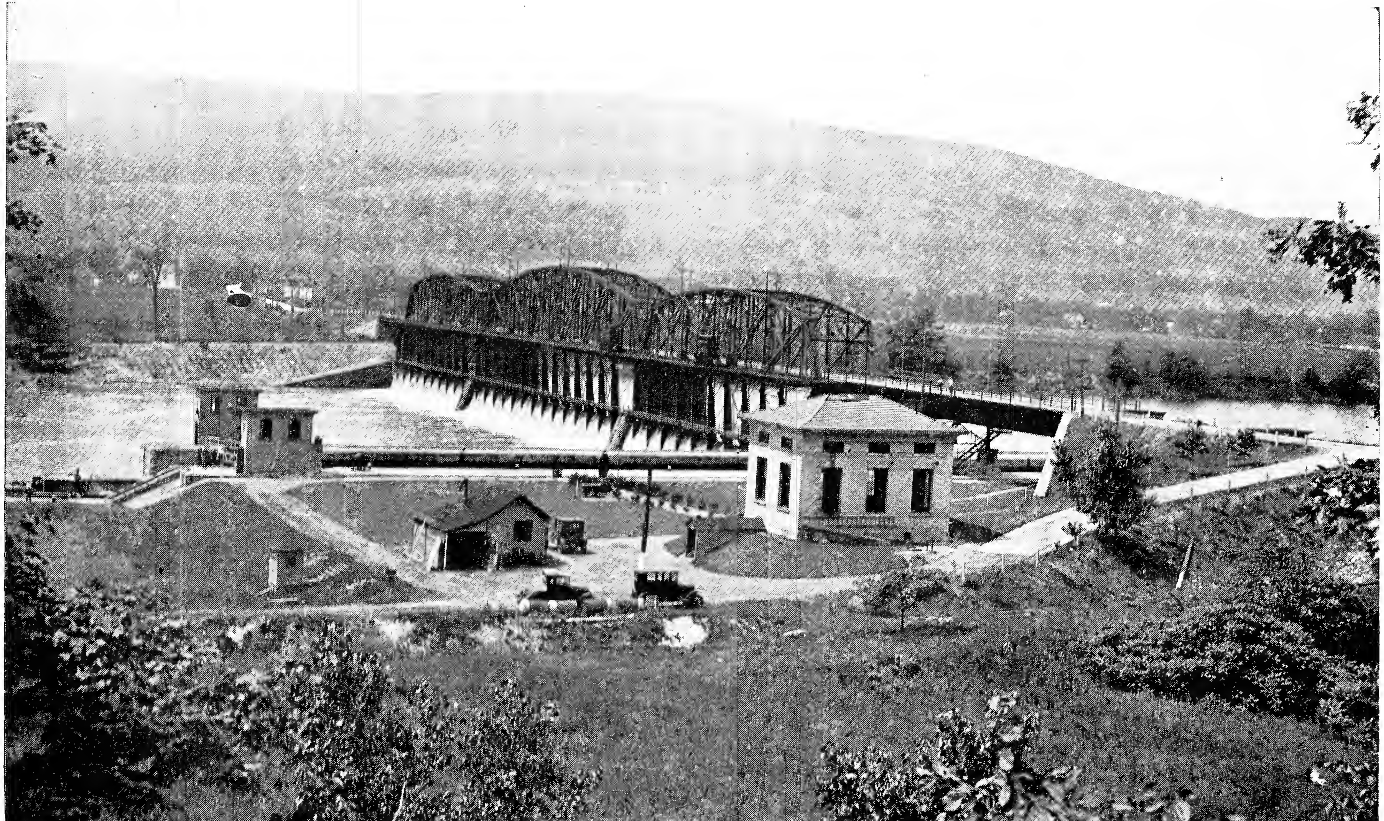

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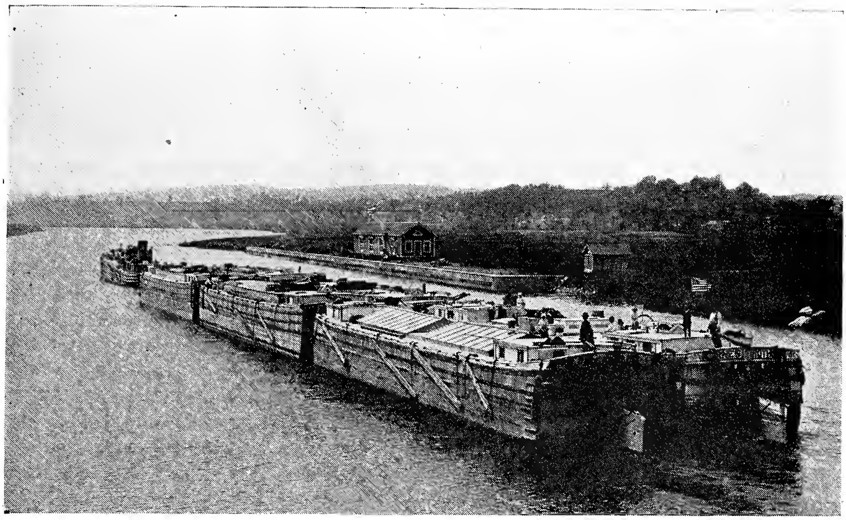


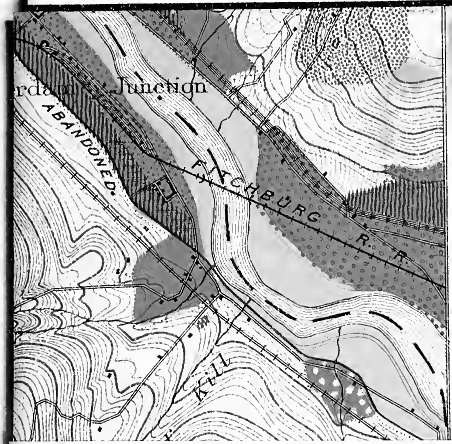
Figure 70 Tow of canal boats in Barge canal. From Fultonville bridge looking west. Part of Fonda on the right, Noses gorge in the distance.

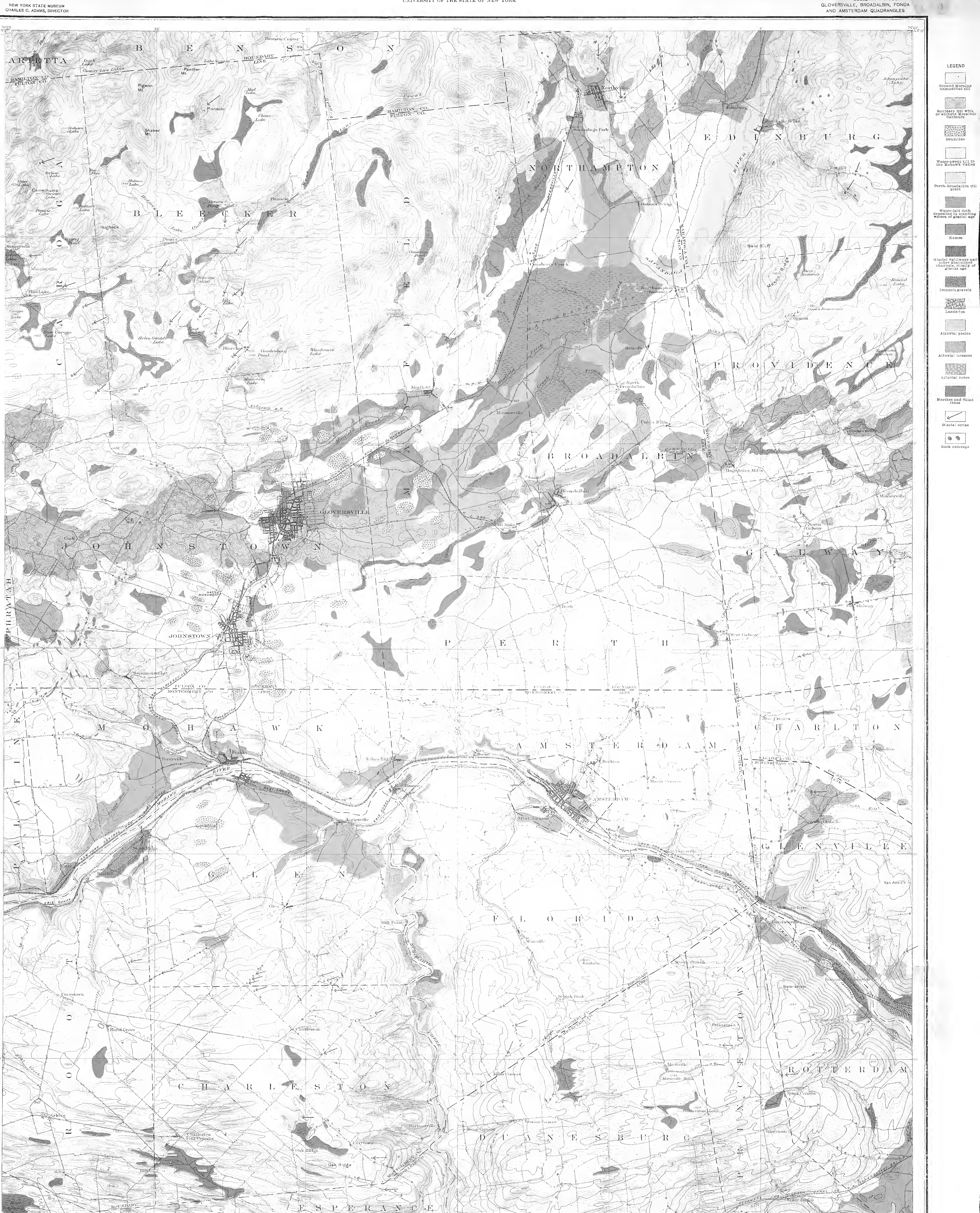
Figure 71 New York Central Railway, looking down the river past Pattersonville. "Yantaputchaberg" in the distance. Photograph by J. Arthur Maney.


Figure 72 Up Chuctenunda creek from Grove street bridge, Amsterdam. Rapids on rock floor afford water power.

Glacial Geologic Map of Amsterdam, Fonda, Gloversville and Broadalbin Quadrangles

BULLETIN NO. 280.
RSVILLE, BROADALBIN, FONDA
AMSTERDAM QUADRANGLES






GLACIAL GEOLOGY AND GEOGRAPHIC CONDITIONS OF THE LOWER MOHAWK VALLEY

Geology by
A. P. Brigham

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

*Datum is mean sea level.*

# New York State Museum Bulletin

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## NEW YORK STATE MUSEUM

CHARLES C. ADAMS, *Director*



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# New York State Museum Bulletin

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No. 281 ALBANY, N. Y. April 1929

## NEW YORK STATE MUSEUM

CHARLES C. ADAMS, DIRECTOR

# THE STRUCTURE OF THE DRUMLINS EXPOSED ON THE SOUTH SHORE OF LAKE ONTARIO

BY

GEORGE SLATER D.Sc., D.I.C., A.R.C.S.

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## INTRODUCTION

In 1924 I paid a visit to the drumlin area of central-western New York, a district, which in the opinion of Professor H. L. Fairchild ('07) contains "the most remarkable group of drumlins in the world when all the facts relating to them are taken into account." The district between Rochester and Syracuse, for example, shows an unusual development of the drumlin-type of topography, which is beautifully delineated on the Clyde, Oswego, Pultneyville and Sodus Bay topographic maps on the scale of one inch equals one mile. Special attention, however, was paid to the series of bluffs on the south shore of Lake Ontario where the internal structure of portions of the drumlins was most clearly exposed. "The coast sections which show the structure to best advantage extend from the neighborhood of Sodus Point to Oswego, a distance of 28 miles." Professor H. L. Fairchild, who examined the shore drumlins 20 years ago, advocates the use of a boat as the "structure can not be seen properly at close range." The structure viewed from a distance is illustrated by excellent plates in his paper cited above. In the present instance the bluffs were examined from the shore, the illustrations taking the form of line drawings. Three convenient centers were chosen from which groups of drumlins were studied. These were Sodus Point, Fairhaven and Oswego.

A boat was hired at Sodus Point in order to reach the drumlins northeast of Sodus Bay, while broader relationships of structure were viewed from a distance by swimming out into the lake.

Owing to a surface coating of mud, portions of the sections had to be cleared, although differences in lithology usually showed in characteristic manner by the drying out of the beds. Many of the sections showed characteristics of general occurrence, but eleven appear worthy of special description; in seven of these sand and gravel are recorded as of structural importance. The dimensions of these drumlins can be obtained from the contoured topographical maps.

## TREND OF THE SECTIONS RELATIVE TO THE GENERAL DIRECTION OF ICE-MOVEMENT

In the area immediately to the north of Lake Ontario the general direction of the movement of the ice-sheet was toward the southwest (Taylor '13). In the central-western part of New York State, the direction of the longer axes of the drumlins is of more radiate

character (see Fairchild '07). In the coastal area between Sodus Point and Oswego these axes have a general north-south trend, while toward Oswego their trend veers round to a direction northwest-southeast. The general direction of the shore line is northeast-southwest, and sections coinciding with this direction are the most instructive, although smaller sections at right angles to the shore occur in the weathered pinnacles of some of the bluffs. The topographic maps bring out the fact that the exposures in the bluffs are transverse sections of the northerly parts of the drumlins in the majority of cases; that is, they occur at the ends of the drumlins which were exposed more directly to pressure from the ice.

## GENERAL DESCRIPTION OF THE DRUMLINS

### Bedding of the Upper Part

The most general feature of the shore drumlins was the presence of what is termed by Professor Fairchild "concentric bedding." This bedded structure was especially characteristic of the upper portions of the sections, the bedding coinciding generally with the drumlin form. The lower portions, although bedded in places, usually consisted of a "core" of extremely tenacious, stiff, boulder clay. The difference in structure between the upper and lower parts is best seen from a distance. Examined from the beach, however, this "concentric-bedding" was found to have a more complex arrangement, the structure being most clearly seen at Lake Bluff (figure 3). Most of the drumlins were overlain or flanked by deposits of sand and gravel, or "rubble" apparently of later formation.

### Composition

The contrast in structure already mentioned suggests that the drumlins are composite in character, the two facies of deposits representing progressive stages of construction, resulting in the formation of a "drumlin within a drumlin." The "concentric" structure was due to wavy or inclined seams of loam with small stones, but especially to seams of comparatively stoneless boulder clay. In addition to clays and loams I found wisps and indefinite layers of streaky sand to be of fairly common occurrence. These were intercalated with the clays and loams and were occasionally associated with irregular deposits of gravel. This structure agrees closely with that of some of the drumlins of the Isle of Anglesey, Wales — what appears to be bedding having been the result of movement along thrust planes.

A detailed account of certain of the drumlins follows.

In plan, the main directions of pressure and movement in drumlins orientated north-south are as indicated in figure 1. As section XY is viewed from the north, if the drawing (*a*) is reversed and the

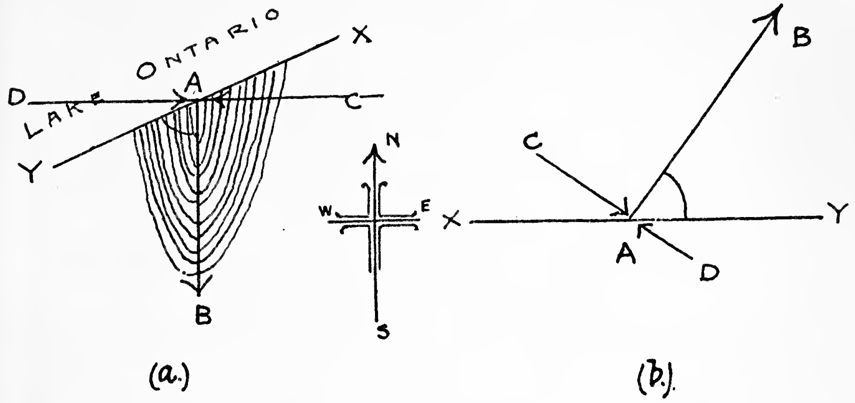


**Figure 1** Conventional Symbols.
(*a*) Contoured plan of drumlin.
*XY* Line of section = Shore line.
*AB* Main direction of movement.
*AD* and *AC* Subsidiary directions of pressure and movement.
(*b*) Conventional symbol for directions of pressure and movement.

section line XY is orientated in a horizontal direction, the directions of pressure and movement will appear as in figure 1 (*b*)

The convention (B) is used with each of the figures. The lengths of the arrows are in approximation to the relative amounts of pressure and movement, the longest arrow *AB* representing the greatest amount, as shown by the longitudinal axis of the drumlin. Applied to a section, *AB* indicates a movement away from the observer, this line making an angle (*BAY*) with the line of section.

Pressure indicated by *AC* is represented as greater than that of *AD*, these two directions of lateral pressure being at right angles to that of the longitudinal pressure *AB*.

I am indebted to my friend Howel Williams M.A., D.Sc., for the idea of this conventional symbol.

## DETAILS OF THE SECTIONS

### Drumlins in the Neighborhood of Sodus Point

1 **Nigger Hill.** 4 miles west of Sodus Point (Fairchild, '07, pl. 46). The height of this drumlin is about 90 feet, the direction of the section varying from east-west to northwest-southeast.

Commencing at the western end, at the edge of the adjoining wood, an outcrop of slabby, hard, jointed micaceous sandstone occurred on the shore for about 200 yards; the upper surface of the rock was somewhat wavy and rose to a maximum height of four feet above the lake, the surface sinking both to the east and west. The change in direction of the cliffs coincided with the highest part of the section, the distance of this point from the edge of the wood at the west being 1100 feet and the line of section between the two points running east-west. The upper part of the bluff at this, the highest part of the cliff, showed curved light bands ("foliated drift"), this structure being seen in sections both north-south and east-west

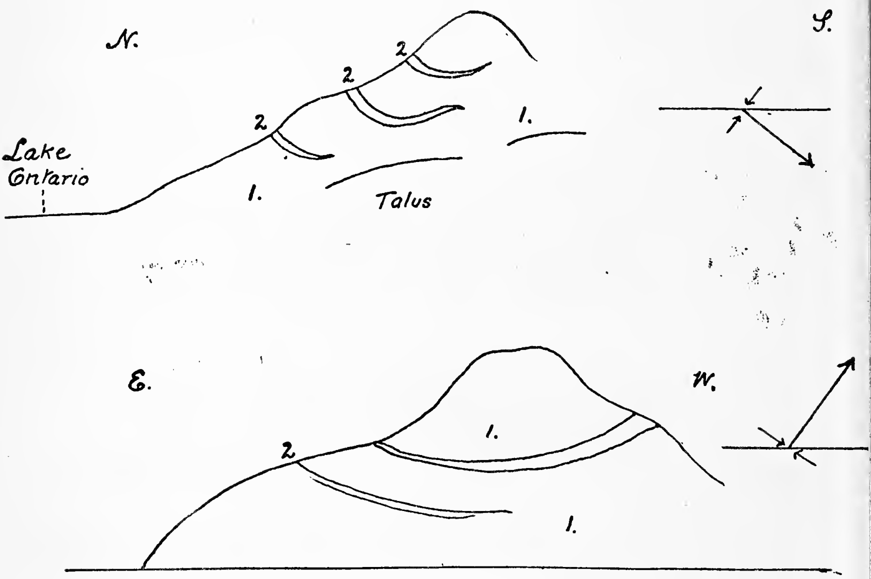


Figure 2 Nigger hill, 4 miles west of Sodus Point.
Foliated drift material.
1 Unbedded boulder clay.
2 Curved lighter bands "foliated drift." The "bands" occur in the upper 30 feet of the cliff. The two sections are adjacent to one another.

(figure 2) . The localizing of contorted layers at this point is of interest, as suggesting the "iceward" side of the drumlin exposed to pressure from the north or northeast. At a point 700 feet from the edge of the wood the bedded layers occupied 22 feet of the cliff, this zone commencing 25 feet from the level of the lake. Moreover, these bands were roughly horizontal, as seen in north-south sections. Between 300 and 700 feet from the edge of the wood

the "bands" in the drumlin rose upward and I saw them best by swimming out into the lake and viewing them in the evening light.

Westward of this bluff the drumlins of the shore area disappear, but a few occur at Charlotte, the port of Rochester, 36 miles west of Sodus Point.

2 **Lake Bluff.** Situated northeast of Sodus Bay, about 2 miles east of Sodus Point (Fairchild, '07, pl. 44).

This bluff is from 80 to 90 feet in height and the section has a main direction northeast-southwest. In many respects it was the most instructive section examined.

The drumlin displayed composite structure; the lower portion with a maximum depth of 50 feet, consisted of stiff reddish unbedded boulder clay which became slightly bedded above.

The upper portion of the drumlin, some 22 feet thick, consisted of bedded stiff clays and nearly stoneless bands of hard clay, associated with sand and loams.

The arrangement of the upper deposits in the form of inclined planes over the curved surface of the lower boulder clay was extremely interesting and proved that the accretion of the drumlin material was due to the passage of new material along thrust planes, due to pressure and movement approximately from the north and possibly the east (figure 3).

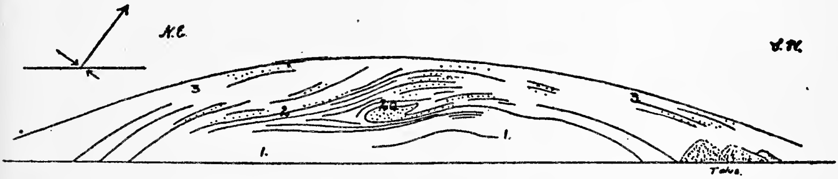


Figure 3 Lake Bluff, northeast of Sodus bay.

1 Stiff boulder clay with numerous boulders and small stones. Bedded in the upper part but marked off sharply from the beds (2) above. Thickness about 50 feet.

2 Bedded stiff clays or hard loams with lenticles of clayey sand. The clay passes to nearly stoneless bands. Streaky sand (*2a*) increases toward the center of the section and is associated with thin beds of clay. The beds are slightly contorted in places. Thickness about 22 feet. The division planes associated with the sand have the characteristics of thrust planes.

3 Bedded sandy rubble of later formation. Thickness variable.

In this section the sand which occurred in the more central part of the drumlin between the upper and lower deposits had formed the surface over which the hard stoneless bands of clay had been thrust, the junctions between the various beds having the characteristics of thrust planes. A little bedded sandy rubble occurred on the flanks and appeared to be of later formation than the drumlin.

3 **Bluff one mile northeast of Lake Bluff.** This bluff was the first bluff encountered after leaving Lake Bluff and walking a mile along the shore to the northeast. It appears to be the one adjacent to that described by Fairchild ('07) as Cline's Bluff.

This small bluff is worthy of note, although only some 40 feet in height, as it illustrates the denudation of the southwestern flank and the deposition of later material; the lower gravel was deposited unevenly upon the surface of the drumlin, and the upper deposits of gravel and sand passed laterally into lower deposits of loam, which were contorted some little distance away. This drumlin showed no clear signs of bedding (figure 4).

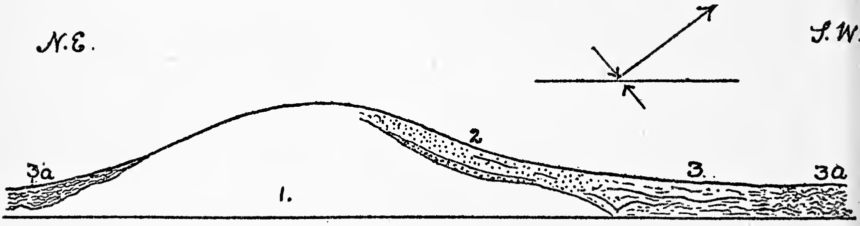


Figure 4 Bluff, one mile northeast of Lake Bluff, adjacent to Cline's Bluff. Denudation of the southwest flank of a drumlin.
1 Drumlin composed of unbedded boulder clay. Height of cliff up to 40 feet approximately.
2 Coarse gravels and sand
3 Loam up to 12 feet, becomes contorted at *3a*. This deposit passes laterally to (*2*).

4 **Chimney Bluff.** Two miles northeast of Sodus Bay. Height 150 feet. (Fairchild '07, pl. 43)

Although this is one of the most impressive drumlins on this shore, and showed erosion forms of great interest, the amount of structure recorded does not call for any detailed description.

The lower portion of the drumlin consisted of unbedded stiff clay but the upper part was bedded, and about three feet of coarse gravel occurred on the top for a short distance. This was, however, well marked off from the drumlin.

Sections at right angles to the lake shore displayed the bedding to best advantage. The "wavy lines" were roughly horizontal but detailed examination was impossible owing to the precipitous cliffs (figure 5).

5 **Blind Bay Bluff.** Between East Bay and Port Bay. One and one-half miles east of East Bay, five miles northeast of Sodus Bay (Fairchild '07, p. 45).

The upper part contained many small boulders in rubbly drift, and the clay was sandy. Below, the clay was of a grayish character

and roughly bedded. Horizontal bedding was a characteristic of sections at right angles to the direction of the shore line, and this bedding extended down the cliff. The drying out of various beds gave a patchy appearance. The cliffs weathered into knife-edge bluffs. Streaky sand lenticles of irregular extent were noted. On another part the following observation was made: "All the upper half is well bedded and about half way up is a good lenticle of gravel with gray bedded clay above and below. The section ran east-west, and there was a slight dip of bedding to the west." The bedded gray clay was full of small stones, and layers of sand were

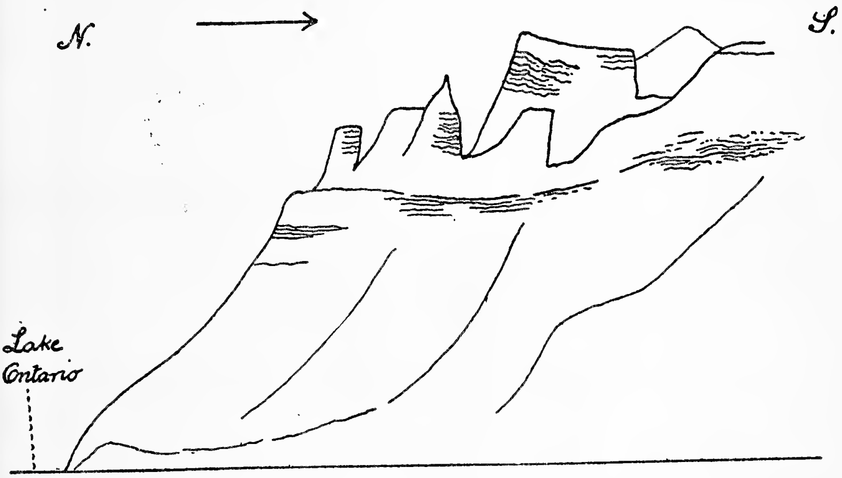


Figure 5 Chimney bluff. Section at right angles to the shore.
The section shows a very indefinite and irregular bedded structure in the upper part, with many irregular whitish patches giving the cliffs a speckled appearance. The upper cliffs were inaccessible. Height 150 feet.

fairly continuous. About three-quarters of the cliff, which was probably about 100 feet in height, was bedded. Elsewhere another rubbly lenticle of gravel was seen, as well as "stringy sand-lenticles." Then suddenly toward the west, structure ceased, and the cliffs were full of rain channels. The sand died out as wavy bands.

### Drumlins in the Neighborhood of Fairhaven

**6 First bluff east of the Pond adjoining Little Sodus Bay.** Commencing at the southwest end a section northwest-southeast was of interest since it showed an intermediate band of roughly bedded and stratified sand and clay lying between the upper and lower boulder clays (figure 6, *a*). The relative position of the bed (*a*) agreed with the position of similar deposits in some other sections;

a similar band has also been recorded in one of the drumlins of Anglesey (Greenly, '19).

A little farther to the northeast the upper 15 feet or so of the cliff was roughly bedded but farther on the whole cliff seemed to be unbedded. Boulders on the shore were mostly red micaceous sandstone.

7 **Bluff southwest of Juniper pond.** The eastern section gives a transverse section of the drumlin, the section having a northeast-southwest trend.

The lower part of this drumlin was faintly bedded and formed somewhat steep slopes, the upper part being less precipitous. Be-

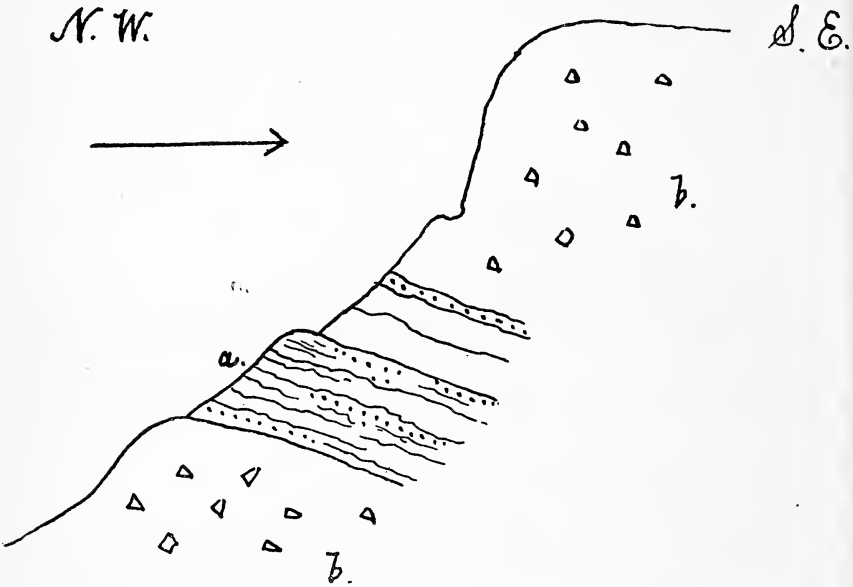


Figure 6 Bluff east of "the pond," Fairhaven, N. Y., adjoining Little Sodus bay. Bedded sand and clay in a drumlin.
(*a*) Layers of sand and clay roughly bedded and stratified. Boulder clay (*b*) above and below. Thickness of (*a*) six to ten feet, but this bed is only a local development.

tween the two the bedded structure was well shown, especially in sections northwest-southeast in the cliffs. The most interesting part of the section was the presence of a well-marked band of sand and gravel. It occurred near the junction of the upper and lower cliffs near where the change of slope occurred. It dipped as a slight hollow to the west and formed a good division plane, then it sank lower to the west and died out. Sand occurred below the gravel and rested upon faintly bedded and unbedded boulder clay. It was overlain by "streaky" boulder clay.

Toward the southwest where the surface of the drumlin sloped downward, the cliff was about evenly divided into two series of beds; the lower half was composed of boulder clay, and the upper

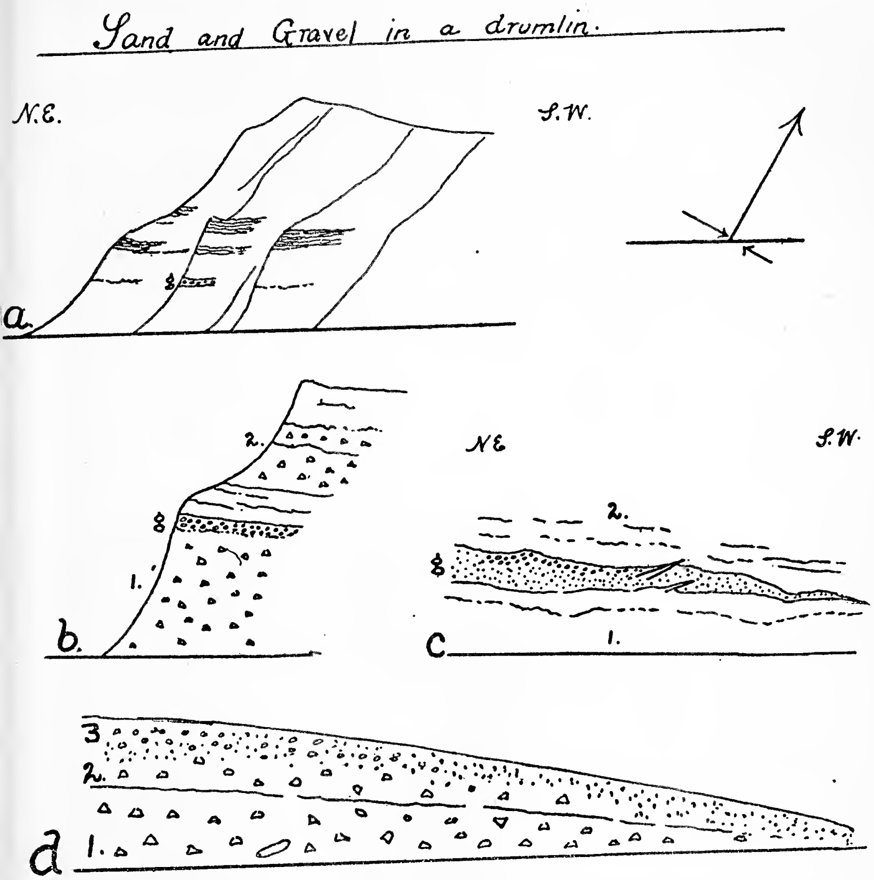


Figure 7 Bluff southwest of Juniper pond, Fairhaven, N. Y. Sand and gravel in a drumlin.
*a* Section in bluff showing bedded structure. g = gravel.
*b* Section in bluff.
1 Boulder clay mostly unbedded.
2 Boulder clay with streaky bedding. g = gravel.
*c* "Pinching" out of gravel and sand (*g*).
*d* Southwest end of drumlin.
1 Boulder clay with large boulders.
2 Boulder clay with few boulders.
3 Gravel and top soil.

part of the section consisted of clay with scattered boulders overlain by gravel, sand and loam, the division line of junction between the two being roughly stratified in one part. The well-marked de-

posit of sand and gravel referred to above is recorded in Fairchild ('07) as being the only example of such material known to the writer definitely associated with the drumlin structure in the shore sections, although a similar deposit is also recorded in one of the inland sections of a drumlin (figure 7).

8 **Bluff northeast of Juniper pond.** The section is northeast-southwest.

Commencing at the northeast end, the drumlin rose from the lake and showed about 20 feet of apparently unbedded gray boulder clay, but showing bedding in cross sections overlain by about 10 feet of buff clay which showed irregular bedding. The lower clay became sandy in the upper part a little farther on. Toward the more central part of the section the middle part of the drumlin was well bedded, a zone of bedding about eight feet thick being associated with sand and a little gravel. The upper ten feet of the section was composed

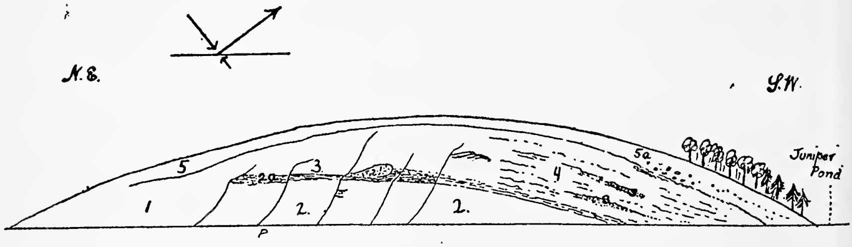


Figure 8 Bluff northeast of Juniper pond, Fairhaven, N. Y.
1 Gray boulder clay undifferentiated (about 20 feet). Streaky buff rubble above (5) at this point about ten feet.
2 Dark gray boulder clay, bedded in places. Irregular lines represent weathered pinnacles (*P*).
3 Bedded zone about eight feet thick; sandy at *2a*; best seen in cross sections.
4 Beds of clay associated with streaky lenticles of sand all dipping down to the southwest. *S* = sand. Bedding chiefly on the southwest side.
5 Buff-colored rubble, very coarse at *5a* with indefinite junction below, up to ten feet.

of yellow rubbly drift; the rest of the section was composed of dark gray clay with light bands of sand.

There was a most decided dip of the beds to the southwest, the whole of the cliff toward this direction consisting of streakily bedded clay intercalated with irregular seams of sand. At the wood adjoining Juniper pond these were overlain by coarse rubble.

The arrangement of the beds in this section suggests deposition associated respectively with iceward and leeward sides of an obstruction cut diagonally across the strike (figure 8).

9 **Drumlin just west of Blind Sodus Bay.** The chief feature noted in this drumlin was the general presence of streaky sand interbedded with boulder clay. The section was northeast-southwest.

Nests of gravel occurred in the upper part of the crest of the drumlin, and was also seen on the northeast slope resting on bedded loam. On the southwest slope sand and loam occurred in the top part for about 11 feet, small contortions also being seen. On the lower part of the southwestern slope, a strong rubbly bed of gravel full of red boulders occurred. This bed was of later age than the drumlin and cut irregularly into the bedding below.

Judging from the outline of this drumlin on the map the shore section appears to be more longitudinal and cut through the beds forming the "flank" of the drumlin. If the section were cut farther back evidence of thrust would presumably appear at the northeast end as in figure 3 (figure 9).

**10 Drumlin southwest of the previous one.** Section northeast-southwest.

Commencing at the northeast end the lower portion showed unbedded boulder clay. Farther on this became more sandy above and still farther on passed into a layer of gravel overlain by streaky beds,

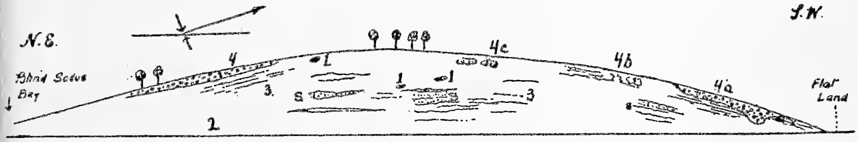


Figure 9 Drumlin just west of Blind Sodus bay.
1 Boulders. Large boulders of gneiss etc., on beach.
2 Boulder clay.
3 Bedded boulder clay, with loams bedded below 4. Contains lenticles of streaky sand in places (*S*).
4 Gravel and boulders. *4a* Rubbly band full of red boulders and gravel. *4b* Bedded and contorted loam. *4c* Nests of gravel, sand and loam.

The upper ten feet consisted of well-defined buff-colored beds; below these the clay was sandy and showed irregular bedding in pale gray clay. From the west of the drumlin to the southwest the lower boulder clay was unbedded but was overlain by bedded material about 15 feet thick. Then occurred about 15 feet of loamy or marly bedded sand. The layers of fine marl were numerous with many layers to an inch. The sand was very soft to the touch. The arrangement of the sand relative to the drumlin structure was noted. In my field notes I have written: "The sand appears to lie in a pocket and thins out. It is overlain and underlain by boulder clay. Smaller adjacent deposits of gravel occur. The main mass of marly sand also thickens irregularly to the southwest and is overlain by gray boulder clay. The upper part of the section, until it becomes overgrown, consists of about ten feet of rubbly material resting

on a sandy bed which overlies the boulder clay and the sand described." The opinion expressed in my field notes is "that the sand and the gravel represent included masses in the drift." Their arrangement supports the view that they are analogous to boulders, the rubbly top layer being of later date (figure 10).

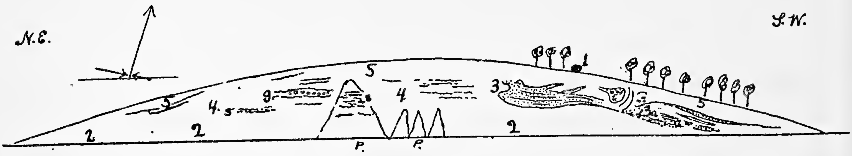

Fig. 10 Drumlin southwest of Blind Sodus bay. Southwest of figure 9.
1 Boulder of white gneiss 6 feet x 4 feet x 5 feet.
2 Gray boulder clay, undifferentiated below and weathered into pinnacles (*P*).
3 Fine marly sand with marly bands, up to 15 feet. At 3*a* marly sand thickens and is overlain and underlain by gray boulder clay.
4 Bedded pale gray boulder clay, containing lenticles of gravel (*g*), and streaky sand (*S*), passes into 3.
5 Buff-colored rubbly top-deposit, about ten feet. Contains red sandstone boulders in places.

## Drumlins in the Neighborhood of Oswego

Two main bluffs were examined southwest of Oswego. Lewis Bluff between Rice creek (or Three-mile creek locally) and Snake creek, and a large bluff between Snake creek and Eight-mile creek.

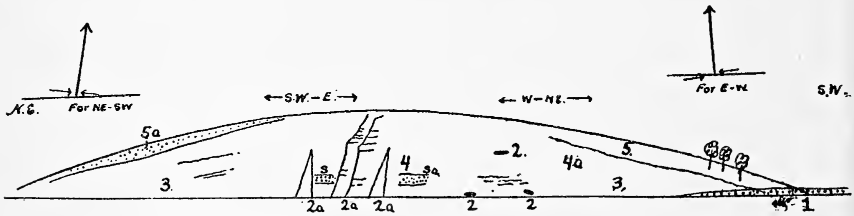

Figure 11 Bluff between Snake creek and Eight-mile creek, southwest of Oswego.
1 Outcrop of sandstone. Rounded surface, covered with rectangular blocks of sandstone with rounded corners, the surfaces of the "blocks" all sloping down to the lake. A rounded boulder of gneiss also seen. A huge erratic in the lake adjoining. Exceptional number of erratics on the beach. One of red gneiss 8 feet x 6 feet x 4 feet.
2 Large erratics of micaceous sandstone. 2*a* Denuded pinnacles.
3 Gray boulder clay, mostly unbedded.
4 Bedded boulder clay, contains sand at *S*. At 5*a* six feet of sand coated with a skin of mud-wash, weathered as a dark patch. At 4*a* no particular structure, and not distinguishable from (3) below.
5 Top deposit, sand at 5*a*, light clayey material at 5.

The former does not call for special description, consisting of pale gray boulder clay overlain by sandy rubble. The tabular rock was seen on the shore at Rice creek (figure 11).

**11 The Bluff between Snake creek and Eight-mile creek.** This (figure 11) is a large drumlin and has a striking appearance from a distance. The line of section varied, the main direction being east-west. Commencing at the northeast and apart from a few darker patches no particular structure was seen, but where the section became east-west in trend a band of sand up to six feet was noted comparatively low down the cliff. Here the cliff was bedded from the sand to the top of the cliff. Sand was also noted at a similar level farther on, but was coated with a "skin" of washed down clay and dried out as a dark patch. This bedding died out from the east toward the west and apart from the presence of three large erratics of angular micaceous sandstone, nothing of special note was seen.

The western slope consisted of gray clay below with lighter clay above and the drumlin ended on a good outcrop of sandstone. The surface of the rock was rounded and was covered with rectangular jointed blocks of sandstone all orientated to the southeast. Gneiss erratics were associated with these. The adjacent drumlin consisted of gray clay with a general absence of red sandstone blocks and I could see no connection between the two.

The map shows that the coast section cuts through the apex of the drumlin and is a section transverse to the main axis. It follows that the "thrust beds" flanking the north part of the drumlin have been denuded to a large extent. The outline of this drumlin on the map is less symmetrical than most of those described. The highest part occurs near the change of direction of the section (figure 11).

## INTERPRETATION OF THE STRUCTURE

Accepting Professor P. F. Kendall's definition that "a drumlin is a *roche-moutonnée* expressed in boulder clay" ('24) the "cores" of stiff boulder clay forming the "heart" of the drumlins described may be regarded as early drumlins which have acted as obstructions to the passage of later material. The shore sections show the underlying country rock in only a few cases and throw no fresh light on the initial causes of drumlin formation. On the other hand, the evidence is clear that the "cores" have acted as obstructions to the passage of later material, and the problem presented is that of their relationship to the later progressive stages of drumlin formation. In other words, we are dealing with a particular case of the wider problem of the behavior of ice when passing over prominences, a subject upon which there is much definite information derived from the study of Arctic Glaciers and disturbed drift deposits (Chamberlin '95 and Slater '24). In the papers just referred to, it is

shown that the relationship and relative interplay between various directions of pressure and movement of ice when meeting obstructions are exceedingly complex. There is one point, however, which deserves special emphasis; the relationship of ice movement to the lithological material with which it is associated. Arenaceous material is the most suitable material for the formation of glide planes, over which argillaceous material is readily transported.

Under the influence of pressure this sandy material takes the form of "streaky lenticles." Such material has been described as occurring in drumlins in various areas, and I have shown in the present paper that sandy lenticles also occur as structural units in some of the drumlins here described. On the other hand, Professor H. L. Fairchild expresses the opinion that only two cases are known to him in the whole of the New York drumlins where sandy (water-lain) material occurs definitely associated with the drumlin structure. This view is in opposition to the evidence presented here and I was unaware of it until I read Fairchild ('07) at leisure on my return to England. I am glad to find, therefore, in my field notes that I have definitely written "sand" or "gravel" when such material was seen to be of structural importance, although its presence or absence was not systematically searched for. It was quite clear, however, that the surface coating of mud masked such deposits, which therefore could not be seen from a distance. Hence I suggest that the progressive differentiation of the structure of the drumlins has followed *pari-passu* with a progressive lithological differentiation of material incorporated in the ice, presumably associated with a waning power in the movement of the ice sheet. By this means the structure becomes increasingly apparent toward the upper part of the drumlins, although argillaceous material is dominant throughout.

The effects of pressure and movement as seen in longitudinal sections of obstructions of *roche-moutonnée* form have long been known. The "iceward" side is associated with the formation of thrust planes in the englacial material, while the leeward side shows lessened pressure and the formation of deposits of tip-heap structure.

Lateral pressure also occurs and is seen in transverse sections, especially where the obstruction is oval-shaped or lenticular in form. This lateral pressure is shown by contorted beds in a transverse section of one of the drumlins of Wisconsin (Alden, '05). The transverse section (figures 3, 8 and 10 of the present paper) appear to support the view that the lateral pressure on one of the flanks of the drumlins was greater than the pressure on the other flank, the latter showing some resemblance to deposition on the leeward side. I have also proved that lateral pressure occurs in Spitsbergen

glaciers ('25) and further proofs were seen in the sections around Wallasay, England, where obstruction to the movement of the ice was caused by the Keuper outcrop ('25). It seems clear, therefore, that the oval-shaped drumlin form is a geometric structure representing an "area of equilibrium" of pressures acting in various directions, and presents an interesting problem in the science of physics.

## SUMMARY

1 The drumlins on and adjacent to the southern shore of Lake Ontario are of unusual size and development.

2 The sections are usually transverse and lie across the exposed or "iceward" ends of the drumlins.

3 Two phases of structure are shown, marked by a gradual change in the lithology. A lower "core" of stiff boulder clay passes gradually into bedded material above, consisting of stoneless clays, loams, and boulder clay, associated in some cases with "wisps" and lenticles of streaky sand.

4 The "core" has acted as an obstruction to the passage of later material, resulting in the accretion of new material, which has moved along "glide" or thrust planes, thus producing suitable gradients.

5 Pressure has occurred both longitudinally and laterally, the former being predominant.

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# RECENT FINDS OF QUATERNARY MAMMALS AT SYRACUSE, NEW YORK

BY

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The following note is submitted as a contribution to quaternary mammal records. During the late spring and early summer of 1925 a cellar excavation was made in the yard of Croton School, which is situated on the south side of East Raynor avenue, between Leon street and Thomas avenue, Syracuse, N. Y.

Most excavations in this part of the city show pond and swamp deposits. The Croton School section was unusual in disclosing at base a sloping bed of gravel and sand. This was overlain by tufa and then by an irregular series of thin marl and peat layers. The depth of the excavation was about 10 or 12 feet. Wherever observed, artificial cinder fill (two or three feet) covered the whole. The sand and gravel occupied some four feet of the eastern part of the section but passed westward out of sight with an initial dip of about 14 degrees. The rock wall of Onondaga valley is little more than 200 paces east of this locality. The sands and gravels are therefore best interpreted as the sloping near-shore bottom of a small lake or pond whose level stood at about what is now the 400-foot contour. The deposits shown in this section were not actually seen to overlie glacial material. They are part, however, of the valley-bottom lake and swamp series which completed, or, nearly completed, the land surface of the present lowlands. One can hardly regard them as anything but postglacial in age. They probably were formed at a time nearer to the present than to the epoch of ice margin retreat.

Except for these points of geological interest, the section at Croton School was like many others. Its proximity, however, to the Syracuse Bison (Underwood, '90, p. 953, 954; Smith, '14, p. 64–72; Hartnagel & Bishop, '22, p. 92–94) locality furnished an incentive for a number of brief visits. On one of these occasions an obscure bone fragment was found. At the writer's suggestion, a watch was kept for bones. Eventually a fragmentary bear cranium was brought to light and generously placed in the writer's care. To this gift was added part of a deer tibia.

Unfortunately these finds were made only shortly before the walling up of the exposure. On this account little opportunity was offered for further investigation. The writer, however, was able to contribute a broken bear scapula to the collection. All the specimens described below have been placed in the New York State Museum.

In the order of their importance these specimens will be briefly reviewed.

1 **The cranium.** Referable to the Black Bear, *Euarctos americanus* (Pallas). Distance from occipital tubercle to anterior end of incisive suture measures approximately 26.9 cm. Not seen in place but horizon and location indicated by the workmen. Believed to have come from about six or eight feet below the natural surface. The specimen is deeply stained, proving inclosure in one of the peaty layers which are interbedded with the marl. It is virtually a left half cranium. The split largely coincides with the median plane. Wherever this split follows a suture, the color of its surface resembles that of the remainder of the cranium. When, however, the fracture breaks across bone, it exhibits a surface of lighter color. This condition suggests a very recent mutilation of the specimen, a mutilation which shortly preceded its discovery by the workmen. Scattering and disappearance of the fragments of the right side might be expected under such circumstances. On the other hand, we are dealing with a young individual, and disintegration along the dorsomedian sutures may be of ancient date. It seems that the question of an artificial mutilation of ancient date must remain unsettled. Two quaternary crania referable to the Black Bear were obtained some years ago near Ley creek (Smallwood, '03, p. 26–27; Smith, '14, p. 65; Hartnagel & Bishop, '22, p. 81, 82), a tributary of Onondaga lake.

2 **The scapula.** A left. This is certainly Bear and with little doubt referable to *Euarctos americanus* (Pallas). The distance from the somewhat worn extremity of the acromion process to the inner edge of the glenoid surface is about 3.2 cm. This indicates an individual considerably smaller than the possessor of the cranium.

3 **The tibia.** This specimen comprises the distal end of a right tibia. It is with little doubt referable to *Odocoileus* and presumably to *O. americanus* (Erxleben). Long dimension of distal articular surface measures about 3.2 cm.

4 **Other bone fragments.** Only one of these is worthy of mention. This specimen is thoroughly stained indicating inclosure in peaty material. It is clearly a limb bone, very probably a fragment of a bear humerus.

Like many of the "Pleistocene" fossils of New York the remains considered in this note are Holocene. They were either entombed in, or, they settled into, materials which can be confidently assigned to the time which has elapsed since the last ice-controlled lake held sway.

In conclusion the writer wishes to express his appreciation of the generosity and enterprise shown by H. J. Davies and Francesco Mignacco, who were engaged in the work of excavation at Croton School.

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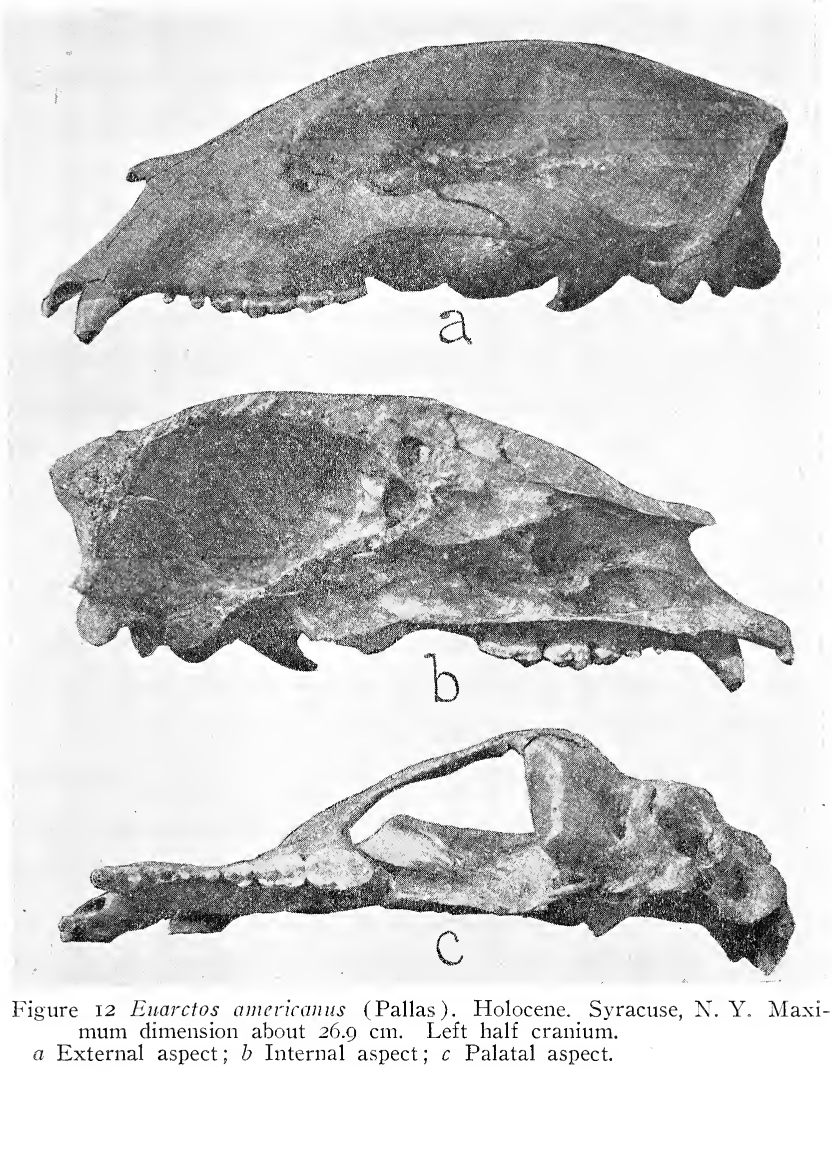

Figure 12 *Euarctos americanus* (Pallas). Holocene. Syracuse, N. Y. Maximum dimension about 26.9 cm. Left half cranium.
*a* External aspect; *b* Internal aspect; *c* Palatal aspect.

# INFLUENCE OF EROSION INTERVALS ON THE MANLIUS-HELDERBERG SERIES OF ONONDAGA COUNTY, NEW YORK

BY

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CONTENTS



## INTRODUCTION

The Manlius-Helderberg series of central New York presents the paradox of being at once simple and puzzling. Most sections show these limestones covered evenly by the quartzose Oriskany sandstone, which in turn is succeeded regularly by the Onondaga limestone. Conditions at any one quarry section are usually quite clear. When, however, the series is traced laterally certain incongruities appear in the various exposures. The sandstone is found at one place resting on a stromatoporoid reef, at another on a thinly bedded blue limestone, or again, on a water lime. The Oriskany may be a 20-foot sandstone, portions of which yield the *Spirifer arenosus* fauna. More often it is a thin stratum of quartz grains, nodules, and perhaps corals grading upward into the Onondaga limestone.

These anomalies may make the geologist considerable trouble when he attempts to correlate the different sections. Most of the difficulties can be grouped under (1) those which are caused by erosion intervals, and (2) those which are due to lateral changes in life or in sedimentation.

This paper is not intended in any way to express a final judgment on the broad question of Manlius-Helderberg correlations. One chief purpose is to call attention to certain stratigraphic units which have been very generally ignored and confused. The distribution of these units may be profoundly influenced by the erosion surfaces which are second in importance only to the strata themselves. Precision demands geographic names for the latter and the abandoning of such terms as "upper water lime." "upper Stromatopora layer," and "diamond blue."

## SUBDIVISIONS OF VANUXEM'S MANLIUS

The term "Manlius" was proposed by Vanuxem ('39, p. 272), was revived by Clarke and Schuchert ('99, p. 876, 877), and has since

become firmly established in geological literature. Vanuxem clearly uses the term in a group sense. He specifies four distinct lithologic units in his original description. These four are unmistakable and the association which they make should stand as the starting point for any revision, restriction or expansion of the term. Vanuxem ('39, p. 273) says, "The upper layers of the group are from three to four feet thick, sometimes subdivided into what are called courses. There are but two layers of water lime separated by bluish black limestone, which is generally disposed to separate into courses, whilst the layer of limestone which is above the upper water lime is broken up by lines of fracture, in all directions."

It is obvious that Vanuxem intended his Manlius to include much more than these four layers which he describes so exactly. As an example, the fossiliferous limestone below quite certainly furnished most of the fossils which are figured in the report of 1842 ('42, p. 112, fig. 23). His reference in the same work ('42, p. 115) to the beds with "replaced columnariae" makes it clear that he also included the fossiliferous strata which in Onondaga valley lie between his fourth specified unit and the Oriskany sandstone.

If then, the term is to be employed with anything like its original value, the group represented comprises six stratigraphic units at the very least.

These six formational members will be given geographic names.

On returning to Vanuxem's description one finds that there are "but two layers of water lime separated by bluish black limestone, which is generally disposed to separate into courses," etc. To these two water limes with their separating blue limestone the term "Elmwood" will be applied. The lower of these two water limes will be designated "Elmwood A," the "bluish black limestone" between the two water limes will be called "Elmwood B," while the term "Elmwood C" will be reserved for the upper of the two water limes. The fossiliferous mass below the Elmwood becomes the Olney member of the Manlius in this new scheme.

There remain two other identifiable units of Vanuxem's Manlius. Without being distinguished they have been classed as Helderbergian or as probable Helderbergian by some authors (Luther, '98, fig. 3; Hartnagel, '03, p. 1165; Hopkins, '14, p. 19, 20). The lower of these is "the layer of limestone which is above the upper water lime" and which "is broken up by lines of fracture, in all directions." the name Clark Reservation is proposed for this unit. The immediately overlying beds with "replaced columnariae" will be called the Jamesville (Vanuxem, '42, p. 115).

**Olney limestone.** This derives its name from Olney station on the Auburn and Syracuse Electric Railroad. This station is situated about 1¾ miles west of the old east quarry at Split Rock, formerly worked by the Solvay Process Company (U. S. G. S. topographic sheets of the Baldwinsville and Syracuse quadrangles). The splendid section at the quarry named has been selected as the

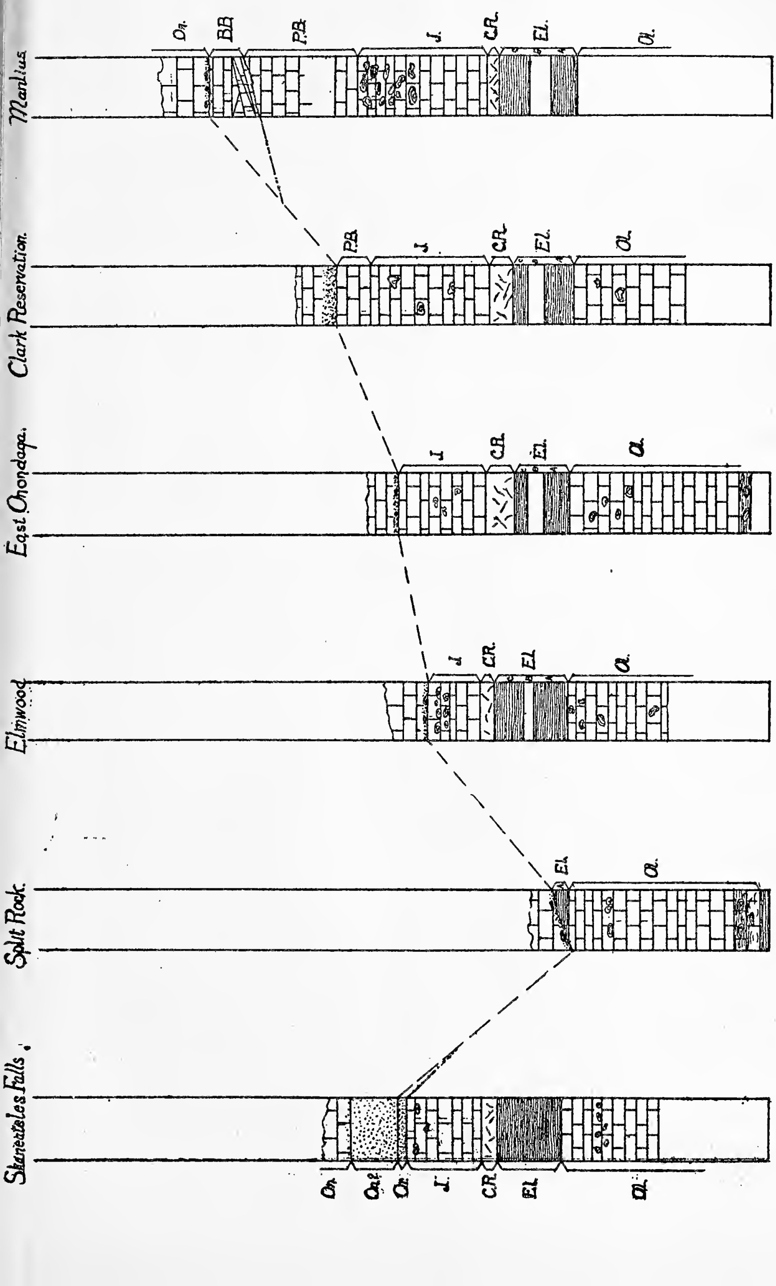


Figure 13 Columnar sections illustrating the more important changes in the passing from Manlius on the east to Skaneateles Falls on the west. *Ol.* Olney limestone. *El.* Elmwood beds, with divisions *A*, *B* and *C* where differentiated. *C. R.* Clark Reservation limestone. *J.* Jamesville limestone. *P. B.* Pools Brook limestone. *B. B.* Bishop Brook limestone. *Or.* Oriskany sandstone. *On.* Sandstone, probably of Onondaga age. *On.* Onondaga limestone, with basal quartz sand and nodules. Lines indicating the probable relations of the erosion surfaces: dashes and dots indicate Bishop Brook erosion, dots indicate Oriskany erosion, dashes indicate Onondaga erosion. The approximate scale for the sections may be taken from the Olney formation at Split Rock. It there measures 33 feet. In the Manlius section the Pools Brook has been estimated at 20 feet. The Onondaga thickness has not been drawn to scale. (Cf. Harris '04.)

type. Unfortunately Split Rock is not available as a formational name. Olney station, though on a different quadrangle from the quarry, is not far away. It is also relatively near very fair exposures of the limestone which it designates. Though the use of Olney as a unit term is not ideal, it is believed that its choice is less objectionable than would be a number of others open to the writer.

This limestone is very largely composed of fine interlaminated blue and drab layers especially in its lower 10 or 15 feet. On fresh surfaces the drab is not conspicuous but a little weathering suffices to emphasize the color which forms such a striking contrast with the alternating blue beds. The upper portion of the Olney is often more coarsely bedded than the lower and frequently contains many stromatoporoids of dark color.

Few exposures, natural or artificial, descend continuously from the Olney into something plainly different. This has, so far, prohibited a scientific determination of its lower limit. Provisionally the base of the Olney is placed at the sharp contact which it makes with a sun-cracked water lime which forms the quarry floor at the type locality. This subjacent water lime is thought to be below, or, at least, near the lower limit of *Spirifer vanuxemi* in central Onondaga county.

Bounded in this manner below, the Olney measures approximately 33 feet in thickness. It is often convenient to regard a zone of from one to three feet as transitional into the overlying water lime (Elmwood A).

The most widely distributed species of the Olney are probably *Spirifer vanuxemi* Hall, *Stropheodonta* (*Brachyprion*) *varistriata* (Conrad), and *Leperditia* cf. *alta* (Conrad). Tentaculites is occasionally found. There are also layers with numerous crinoid fragments and bryozoa. Stromatoporoids may occur at any level in the formation but are more conspicuous and abundant toward the top.

The Olney limestone, as here defined, may safely be regarded as coming within Vanuxem's Manlius. It is also unquestionably represented in the 77 feet of strata which Hartnagel ('03, p. 1165) allows for the Manlius at its type locality. This latter thickness carries the Manlius, as conceived by Hartnagel, far below the base of the Olney, Hopkins ('14, fig. 1) has given columnar sections comparing the Manlius section with several in the Syracuse quadrangle. No scale is specified in these, but one can hardly escape the conclusion that the upper part of the Rondout of Hopkins and the lower part of Hartnagel's Manlius are identical.

**The Elmwood beds.** The type section is at Sweet's quarry about one-half mile northeast of Onondaga Hill and in the belt be-

tween St Agnes Cemetery and Elmwood Park (U. S. G. S. topographic sheet of the Syracuse quadrangle).

Typically the series includes a lower water lime (Elmwood A) and an upper water lime (Elmwood C) separated by a blue limestone (Elmwood B). The writer has been tempted to give these divisions three separate formational names but feels that possibly such a step is premature. Westward Elmwood B disappears and the upper and lower water limes (Elmwood A and Elmwood C) seem to have merged into one continuous formation. It is believed that the series always shows more or less transition from the underlying Olney. Certainly the Elmwood shows close relations with the rocks below. In fact, it might be urged that Elmwood A should be associated with the Olney rather than with Elmwood B and Elmwood C. Such a procedure would be impracticable in western Onondaga county where Elmwood A and Elmwood C can not be certainly differentiated. Above, on the other hand, the series is almost everywhere separated by a sharp contact from the Clark Reservation blue limestone.

Elmwood A is a drab water lime nearly, if not quite, barren of fossils. It is sometimes hard in its lower portions but the greater part is fairly soft. Good exposures may show sun cracks. These are beautifully developed at Split Rock. Elmwood A is about six feet thick at the type section. In general it appears to thin eastward in Onondaga county.

The stratum here designated Elmwood A has been referred to as the "upper" water lime of the Split Rock section (Luther, '98, p. 268; Hartnagel, '03, p. 1158, 1163, 1165). Such an expression implies Elmwood C which together with Elmwood B was removed by Paleozoic erosion. In fact, Luther not only makes a direct correlation with what is here called Elmwood C, but in addition explains what he believes to be the absence of the present Elmwood A.

Elmwood B is a grayish blue limestone beautifully laminated. The upper and lower contacts are quite sharp. It thins progressively from east to west. At Split Rock an old erosion surface has cut below the Elmwood B horizon into the Olney limestone. When farther west the line of unconformity rises above the Olney limestone, it encounters one continuous bed of water lime between the Olney and the Clark Reservation formations. Elmwood B apparently is no longer present. The writer has, so far, been unable to confirm its reported occurrence at Marcellus Falls (Luther, '98, p. 268). The original extension of Elmwood B was presumably obliterated by Onondaga erosion somewhere in the region of Split Rock.

Commonly this member of the Elmwood is unfossiliferous but Hartnagel ('03, p. 1165) has reported *Spirifer vanuxemi* and *Leperditia alta* from Manlius.

Elmwood C is a drab water lime usually very soft. Fine, irregular, folded laminae are frequently exhibited. Upper and lower contacts are usually very sharp. At the type section it is about four feet thick. This member appears to be quite barren of fossils in Onondaga county.

Elmwood C is present and recognizable from Manlius westward to within one and one-half miles of the Split Rock quarries. Field observations do not support the Chrysler section given by Hopkins ('14, fig. 1), in which its absence is implied. As far as the writer has been able to determine, all three divisions of the Elmwood are present in the Chrysler region east of Split Rock.

West of Split Rock, Elmwood C has not been recognized as a distinct unit. It can not there be separated with certainty from Elmwood A, the two making a continuous bed of undifferentiated Elmwood water lime.

**Clark Reservation limestone.** This receives its name from the Clark Reservation State Park slightly over a mile west of Jamesville (U. S. G. S. topographic sheet of the Tully quadrangle). The type section is shown in the cliff south of the lake which is included in the park. Here the thickness is about three feet eight inches. The formation is a compact blue limestone, usually sharply separated from the strata above and below. Probably its best diagnostic feature is furnished by the jagged angular fragments and diagonal cracks which are seen in most exposures.

The thickness, lithologic character, and stratigraphic position of the Clark Reservation leave no room for doubting its identity with Vanuxem's "layer of limestone which is above the upper water lime" and which "is broken up by lines of fracture, in all directions." Vanuxem not only includes this layer in the Manlius but clearly separates it from the overlying beds with "replaced columnariae."

The Clark Reservation is usually unfossiliferous but its physical features are very characteristic and constant. When the eye is once trained in its recognition this thin stratum becomes a most valuable reference horizon.

**Jamesville limestone.** This name is derived from Jamesville, town of DeWitt, Onondaga county (U. S. G. S. topographic sheet of the Tully quadrangle). The type section is shown at the "Green Lake" State Park (Clark Reservation) west of Jamesville. Here it attains a thickness of about 19 or 20 feet, resting on the Clark Reservation member and being in turn capped by a laminated

light blue limestone (Pools Brook) described beyond. In character it is a rather dark blue limestone replete with stromatoporoids and corals. Sometimes the stromatoporoids prevail to such an extent that the minor bedding planes are nonexistent. These latter, however, are often well developed and of a peculiar crinkly appearance.

The Jamesville is best seen in eastern Onondaga county. In the western part of the county the thickness may be much reduced by Paleozoic erosion. In fact, this has accomplished its complete removal at Split Rock and at Marcellus Falls.

That Vanuxem regarded the Jamesville as a member of his Manlius is evident from an inspection of the section given in his final report ('42, p. 115).

## LIMESTONES OVERLYING THE JAMESVILLE

The relations of the Jamesville to overlying limestones can hardly be made clear without introducing two additional formation names. The first of these designates a conformable unit—the Pools Brook. The second applies to a formation of limited geographic extent which unconformably overlies the Pools Brook. It will be called the Bishop Brook limestone.

**Pools Brook limestone.** This formation is named from the Pools Brook valley, along whose southern rim it is exposed (U. S. G. S. tpographic sheet of the Chittenango quadrangle). This is a limestone very finely laminated for the most part. The laminae frequently show gentle foldings. Fresh surfaces are dark in color but the weathered material might almost be described as bluish white. The formation is only sparingly fossiliferous, though Leperditia, corals, and stromatoporoids occur. Its thickness is dependent on the extent to which its upper surface has suffered from Paleozoic erosion. At Manlius a continuous section is not found but a possible maximum of 30 feet may be present. Measured thicknesses at other localities are much less.

The Pools Brook occurs in eastern Onondaga county. It has not been found west of the Onondaga Indian Reservation nor in the northern part of Onondaga valley. At Manlius and along the top of the south wall of the Pools Brook valley its contact with the underlying darker Jamesville is well displayed. For a short distance on the hillside east of Manlius village the Pools Brook is unconformably overlain by the Bishop Brook limestone. Usually, however, it is capped by the basal quartz sandstone of the Onondaga.

The Pools Brook is identified as the "upper blue beds" of Hartnagel's Manlius section ('03, p. 1164, 1165).

**Bishop Brook limestone.** This name is derived from Bishop Brook northeast of the village of Manlius, Onondaga county (U. S. G. S. topographic sheet of the Chittenango quadrangle). The formation is gray in color. Its lower portions are, in places, a mass of crinoid fragments. The upper layers appear to be evenly bedded but cross-bedding has been noted in the basal portions. The fauna is apparently Helderbergian but, so far, unstudied. The Bishop Brook lies unconformably on the Pools Brook. It is in turn covered unconformably by the basal quartz sands of the Onondaga (reworked Oriskany).

In Onondaga county this formation is known only from the hillside east of Manlius village. Its occurrence is here restricted by the unconformities above and below, which seem to isolate the surface exposure completely. In this connection it should be noted that lithologically similar material is present, though thin, in the southern quarry at Perryville, Madison county.

## UNCONFORMITIES (DISCONFORMITIES) TRUNCATING THE SERIES

Three of these erosion surfaces have been recognized. The oldest separates the Pools Brook from the overlying Bishop Brook limestone. The next surface in point of age is covered by the true Oriskany sandstone with its *Spirifer arenosus* fauna. The youngest erosion surface is the most important, having the widest geographic and stratigraphic distribution. It separates the Onondaga limestone, with its basal quartz sand of reworked Oriskany, from all of the units mentioned in this paper.

These three unconformities will be described under the designations Bishop Brook erosion, Oriskany erosion, and Onondaga erosion respectively. In each case the erosion probably commenced before the time indicated by the formational name. It was completed, however, during the initial deposition of each formation in question.

**Bishop Brook erosion.** So far as known, this is confined to the hillside east of Manlius village. The erosion depression is in the Pools Brook limestone. The surface of the depression is covered by the Bishop Brook limestone. This latter is in turn truncated by an upper unconformity.

The contact between the Bishop Brook and the Pools Brook is markedly irregular where the upper formation is thickest. Good-sized fragments of the lower formation may be seen imbedded in the upper.

The Bishop Brook is capped by a thin but definite band of quartz grains and nodules which, with little doubt, represents the reworked

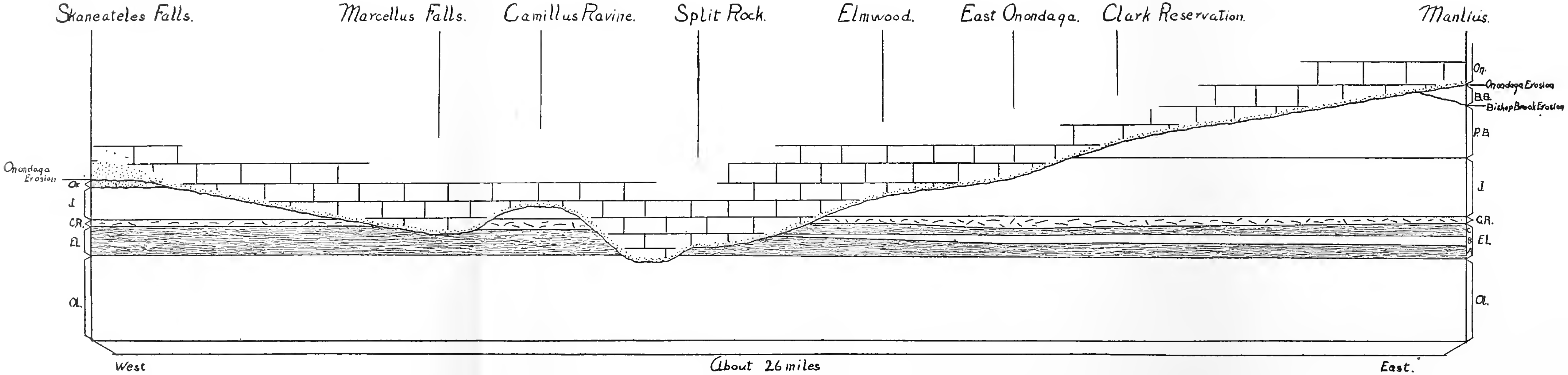


Figure 14 Diagram section illustrating the more important relations of the Onondaga erosion surface between Manlius and Skaneateles Falls. Minor undulations not shown. The true Oriskany sandstone is omitted except at Skaneateles Falls. *Ol.* Olney limestone. *El.* Elmwood beds, with divisions *A, B* and *C* were differentiated. *C. R.* Clark Reservation limestone. *J.* Jamesville limestone. *P. B.* Pools Brook limestone. *B. B.* Bishop Brook limestone. *Or.* Oriskany sandstone. *On.* Onondaga limestone with basal quartz sand. (Cf. Luther '98.)

Oriskany of Onondaga age. In any case the Bishop Brook lies *below* and not *above* a quartz sand. This point must be stressed, for Kindle ('13, p. 304, 305, and fig. 1, p. 305) in a very excellent paper has unfortunately used the unconformity below the Bishop Brook to illustrate the erosion surface immediately below the Onondaga.

**Oriskany erosion.** This produced the surface on which lies the true Oriskany sandstone with, typically, the *Spirifer arenosus* fauna (Eaton, '21, p. 428, 429). The absence of this fauna from the sandstone of any one section is not positive proof that the stratum in question should be ruled out of the Oriskany. Nevertheless, the belief is here expressed that the majority of such cases represent reworked material of Onondaga age. It should be recognized, however, that there are many localities in Onondaga county where the age of the quartz sandstone is open to debate.

The contact of the Oriskany with subjacent beds is sufficiently irregular in minor details to indicate unconformity of the disconformity type. Further evidence for such a structure is given by the section at Britton's quarry (near East Onondaga) and at Skaneateles Falls. At these localities the sandstone with *Spirifer arenosus* rests upon the Jamesville limestone. Absence of the Pools Brook from these sections, especially absence from Britton's quarry, points to its removal by Oriskany erosion.

**Onondaga erosion.** The broad results of this erosion have been discussed by Kindle ('13, p. 301–19). It remains to demonstrate an importance in the local stratigraphy and to call attention to a controlling influence in the distribution of most Manlius-Helderberg units for the region in question.

Many sections in Onondaga county show an erosion surface which is followed by a quartz sand grading upward into typical Onondaga limestone. This basal sand may contain noncommittal material, or it may be full of what appear to be Onondaga corals, but the *Spirifer arenosus* fauna is lacking. It is believed that in the majority of such cases the sand grains represent reworked Oriskany and that this reworking resulted from the erosion which preceded and accompanied initial deposition of the Onondaga limestone. Contacts interpretable in this way seem to be the prevailing ones in the district studied.

As might be expected, the vagaries of this Onondaga erosion surface are most manifest in those directions displaying the longer outcrops. Consequently the more important east-west changes will be noted first. A brief reference to some rather surprising variations in the shorter north-south outcrops will follow.

Beginning at the east this erosion surface cuts out the Bishop Brook in the Manlius Region. No trace of this member is found west of the Manlius east hill. Between Manlius and Jamesville and between Jamesville and the southern part of Onondaga valley (Indian Reservation) the basal quartz sands of the Onondaga rest upon the Pools Brook except in cases where the Oriskany is present. In a line between Jamesville and East Onondaga (northern Onondaga valley) the Pools Brook disappears. At this latter locality the sand is seen lying on the Jamesville limestone, now slightly reduced in thickness. West of Syracuse the progressive elimination of the Jamesville is beautifully shown by its reduction in the successive quarry sections.

Proceeding farther one finds the quartz sand in contact with the Clark Reservation whose thickness may now fall short of a foot (Chrysler region, Syracuse quadrangle). In the east quarry at Split Rock the Clark Reservation, Elmwood C and Elmwood B are missing. Here the erosion has reached downward so as to remove some of the water lime Elmwood A. In the west quarry at Split Rock, Elmwood A is in turn eliminated, the line of unconformity penetrating the upper portions of the Olney limestone and showing a surprisingly rapid descent.

Barring minor local rises, it may be said that the Onondaga erosion progressively cuts out lower and older units of the geologic column as it is followed from Manlius on the east to Split Rock on the west.

West of Split Rock the unconformity passes upward and the Elmwood, Clark Reservation and Jamesville reappear in the belt south of Camillus. A local depression of the erosion surface leads to an absence of the Jamesville and Clark Reservation at Marcellus Falls, where the quartz sand comes in contact with the undifferentiated Elmwood. West of Marcellus Falls the surface again rises restoring for a second time the Clark Reservation, the Jamesville, and at Skaneateles Falls, the Oriskany sandstone. This last condition appears to prevail across the valley of Skaneateles outlet to the Cayuga county line.

In north-south outcrops three variations of the Onondaga erosion surface have been noted. Of these the easternmost is shown on the eastern wall of Onondaga valley between East Onondaga and the Indian Reservation. In this approximately north-south stretch of about three miles the line of unconformity rises stratigraphically toward the south. At East Onondaga the Pools Brook is missing. At the Indian Reservation, on the other hand, it is seen between the Jamesville and the basal Onondaga quartz sand. The highest

stratigraphic level for the unconformity in this belt appears to be near Rockwell Springs north of the reservation. Here the Oriskany sandstone and the Pools Brook are both present. It can not be claimed that all of this removal of the Pools Brook was accomplished by Onondaga erosion. The section at Britton's quarry near East Onondaga shows the true Oriskany lying on the Jamesville, the Pools Brook being absent. This is believed to furnish a strong argument for a considerable removal of the Pools Brook during Oriskany erosion.

The second case of north-south variation is seen in the Chrysler region east of Split Rock. Here, at two localities about 210 paces apart, the Jamesville is absent, or only a trace is present in the northern, but is about two feet thick in the southern. The unconformity rises stratigraphically southward.

The westernmost example of change in a north-south line was found on the east wall of the Nine Mile creek valley near Marcellus Falls. The variation is again accomplished in a short distance. In the space of about 118 paces the Clark Reservation shrinks from a thickness of nearly two feet to three or four inches in going from north to south. About 290 paces farther in the same direction, the section shows no Clark Reservation. The basal sands of the Onondaga are now in contact with the undifferentiated Elmwood. The erosion surface has descended stratigraphically southward.

Acknowledgments are due to Charles E. Wheelock and to Professors George H. Chadwick and Arthur E. Brainerd for helpful suggestions, to Mrs Ethel Ostrander Smith for the preparation of plates and figures, and to Beatrice E. Bolton for reading the manuscript.

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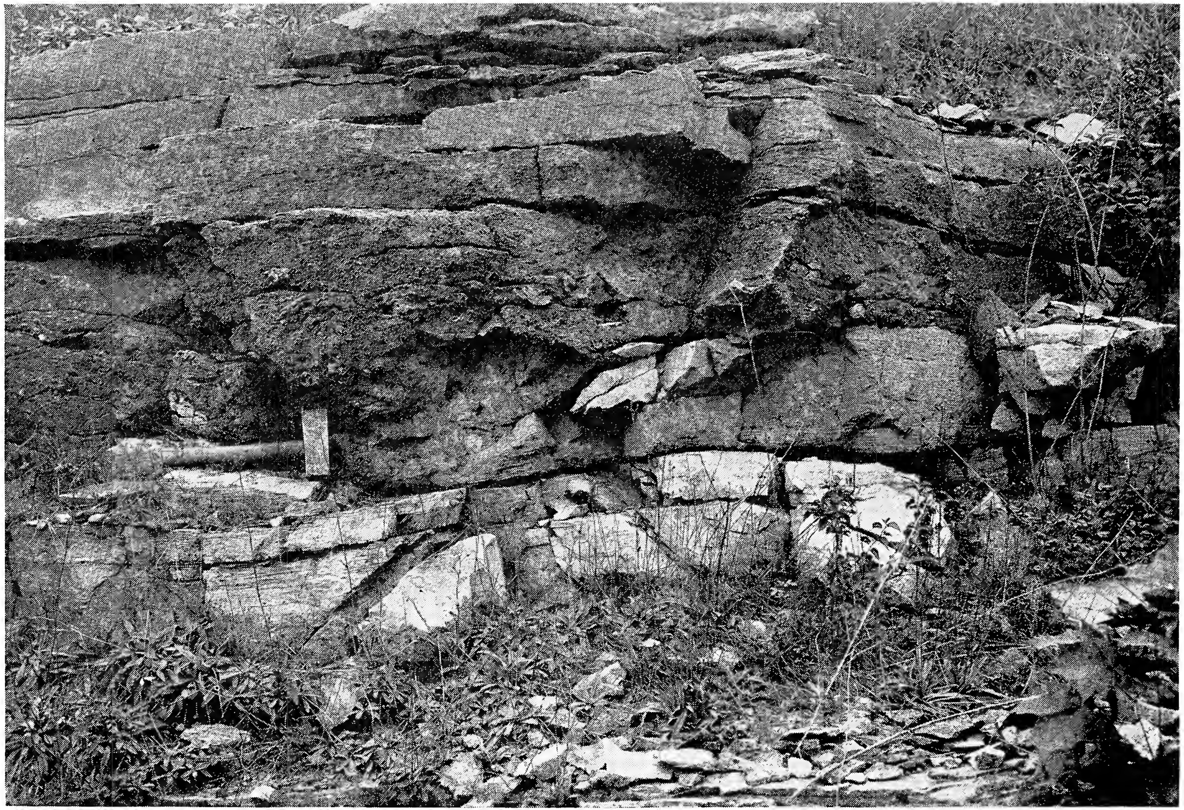

Figure 15 Manlius: hillside east of village. Bishop Brook limestone resting unconformably (disconformably) on the light-colored Pools Brook limestone. The Onondaga basal quartz sand with nodules is not shown in the photograph. It lies stratigraphically above the Bishop Brook. (Cf. Kindle '13.)

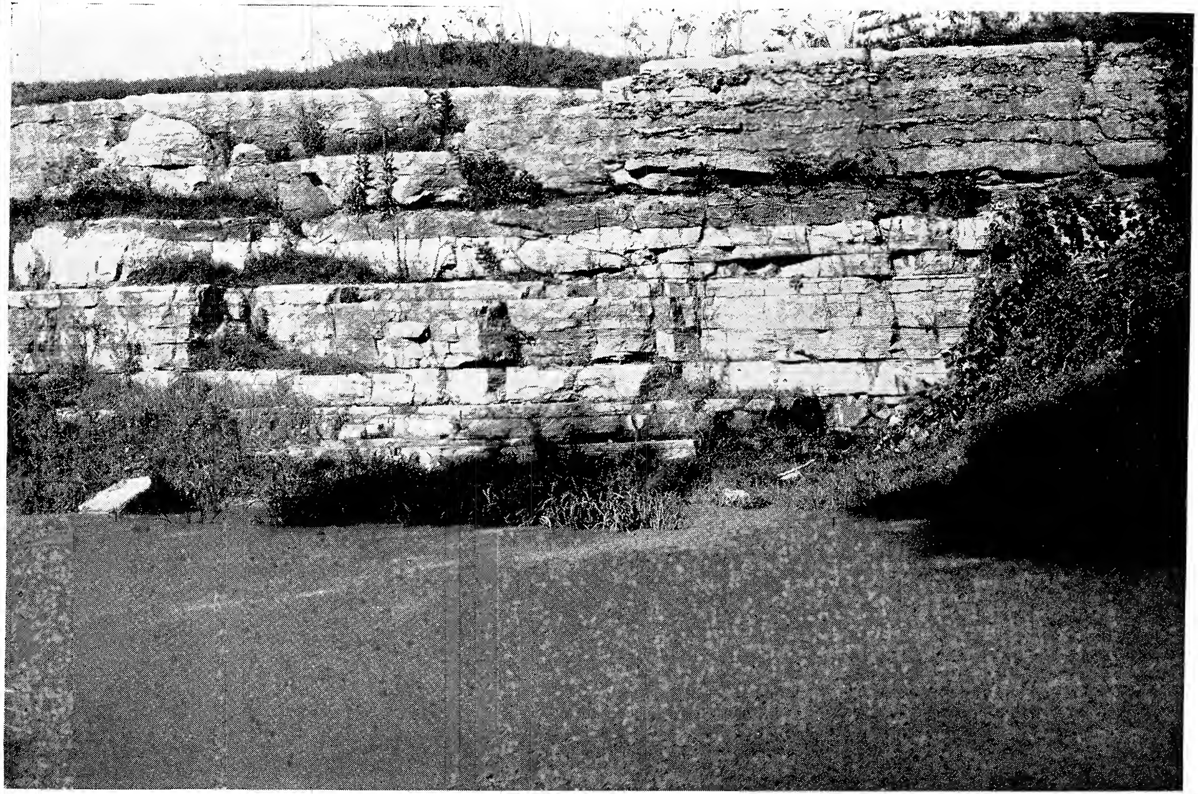

Figure 16 Manlius: hillside east of village. Quarry just north of the Manlius-Eagle road. Bishop Brook limestone, much reduced in thickness, resting unconformably (disconformably) on the light-colored Pools Brook limestone. Chert-bearing Onondaga limestone lies above the Bishop Brook. The Oriskany is absent or represented by a mere trace. The Onondaga basal quartz sand with nodules is much disintegrated. This disintegration causes the space on the quarry wall separating the Onondaga and Bishop Brook. At this locality the Bishop Brook runs from three to 18 inches in thickness. A short distance south of the Manlius-Eagle road the Bishop Brook is missing from the section.

Figure 17 Split Rock: west quarry. Basal Onondaga, with quartz sand and nodules, resting unconformably (disconformably) on interlaminated blue and drab layers of the Olney limestone. Elmwood A has been cut out of the section less than 20 feet to the left of the hammer.

# FOSSIL FISHES FROM THE HAMILTON SHALES OF NEW YORK

BY

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*Honorary Curator of Fossil Fishes, New York State Museum*

The fish fossils herein described were collected by G. Arthur Cooper of the Peabody Museum at New Haven, Conn., who sent them to me for study.

## Arthrodira

### Aspidichthys notabilis, Whiteaves

This rare species is represented by two specimens in the collection. One of them (figure 19) is important because it is the first fragment of the head of this creature that has been recognized, and places the genus definitely among the Arthrodires.

Newberry, who first described the genus, thought it related to Pterichthys. The specimen here illustrated, however, is a typical arthrodiran postorbital plate from the left side of the head and shows the sensory canals of that region as well as the sutures to the central and marginal plates from which it has been torn. It shows, too, the characteristic prominence over the eye found in Dinichthys and Coccosteus.

While the tubercles in this specimen are somewhat smaller than those ornamenting the trunk plates, their general appearance and the texture of the surface of the bone between them leave no doubt in my mind as to the species. The jaws are unknown, but it is probable that they have been described under another name, for instance, possibly, Machaerognathus or Diplognathus.

Another specimen of this fish collected by Mr Cooper is illustrated in figure 18. This is the complete antero-ventro median, one of the bony plates defending the underside of the trunk. It is preserved only as an impression in the shale. I have figured the upper portion of this plate before ('18, pl. 26, fig. 1), but this is the first known specimen showing the complete outline.

The specimens in question were found in the lower Ludlowville (Hamilton) shales of Murder creek near Darien, N. Y., and are preserved in the geological museum of Colgate University. This species has been heretofore recognized from the Cuboides zone of the Devonian in Manitoba, the Conodont bed (Genesee) of Erie county, N. Y., and doubtfully from the Onondaga limestone at Buffalo,

N. Y., the Hamilton limestone of Ontario: the Hamilton of East Bethany, N. Y., and the New Albany black shales near Louisville, Ky.

The type species, *A. clavatus,* Newberry, a larger form is from the base of the Huron shales near Delaware, Ohio, and is known only by fragments of the dorsal and ventral armor. Doubtlessly it has been found in the Schoharie grit (Middle Devonian) and in the Devonian of Germany.

## Elasmobranchii

### Family Gyracanthidae

### Gyracanthus parvulus, n. sp.

**Type.** A nearly complete spine lacking only the extreme tip and the inserted portion of base (figure 22).

**Formation and locality.** Hamilton group, Madison county, N. Y.

Spine very small, but gracefully arched. It is 28 mm in length so far as preserved and 3 mm in greatest width. The sides are compressed, flatter above, gently rounded towards the base. Anterior or cutwater edge thin, with a very narrow, unornamented margin. Posterior margin for more than half of its length armed with stout recurved denticles, whose broad bases are closely adjacent to each other if not confluent. Twelve of these are preserved. Sides ornamented with coarse, smooth, oblique ridges or costae which are more inclined to the axis near the base, and gradually become finer toward the apex. There are about twenty of these costae preserved in the type and probably not many more existed. There is an appearance of minute vertical striations across the ridges and sulci, which is, however, probably due to the enameled surface having worn away, exposing the course of the dentine tubules beneath. The ridges extend to the posterior margin.

The basal opening being imbedded in the matrix if present, it is impossible to determine how far it extended, and as the spine lies in the rock with only one side exposed it is further impossible to determine the shape in cross section.

**Remarks.** This is the smallest of the five or six species of Gyracanthus so far discovered in America. It is closest to *Gyracanthus sarlei,* Hussakof and Bryant ('18, p. 142, pl. 52, fig. 3–5), from the Genesee shale, but differs in the smaller size, in the coarser ornamentation which does not extend to the cutwater margin; and in the presence of denticles on the posterior margin.

From *G. sherwoodi,* Newberry, of the Chemung and Catskill series of western New York and Pennsylvania it differs in its much smaller size and in the direction of its unpectinated striae.

From *G. incurvus,* Traquair, of the lower Devonic of Campbellton, New Brunswick, it differs in its coarser ornamentation, smaller size and in its straighter axis.

The American species of *Gyracanthus* are so far known only by detached fin spines; but since the discovery some years ago of a nearly complete example of a closely related genus, *Gyracanthides,* it is now well established that these are spines of Acanthodian sharks, who bore such defenses not only upon their paired and median fins, but also free on the ventral side of the body.

We may thus expect to find some day a small shark armed with these spines, and whose body is defended with polygonal scales or shagreen, with hard dermal calcifications in the region of the skull, and with orbits surrounded by a ring of sclerotic plates. The genus apparently ranged from the beginning of the Devonian well into the Mississippian.

### Ichthyodorulite

Genus *Gamphacanthus,* S. A. Miller. *Heteracanthus,* J. S. Newberry, Paleoz. Fishes N. Amer. 66, 1889, (preoccupied)

*Gamphacanthus,* S. A. Miller, First Appendix to N. Amer. Geol. and Pal. 715, 1892

### Gamphacanthus cooperi, n. sp.

**Type.** A small, robust spine, one side imbedded in the matrix. Length 30 mm; width at base 12 mm (figure 21).

**Formation and locality.** Hamilton (Mid-Moscow) shales at Keeney, four miles south of Fabius, N. Y. Collected by G. Arthur Cooper.

Spine short and robust, the width at base being contained in the length two and one-half times. Base flat and much compressed. Shaft rounded or subtriangular in section, and curved forward. Anterior (concave) margin broad, smooth and gently arched, bevelled in one direction, its longitudinal axis twisted, or bent. Posterior (concave) margin open for the entire length of the spine, the margins of the sulcus thus formed bearing no denticles. Pulp cavity very large extending nearly if not quite to the tip of the spine. Outer surface of the spine ornamented by broad, flat or even slightly concave ridges comparatively few in number bifurcating and intercalated. These ridges which are worn nearly down to their bases in the type specimen are of unequal width, with wavy margins and are separated from each other by extremely fine, denticulate and suture-like sulci. Nine or ten ridges are to be counted on the flattened base and perhaps as many towards the

apex where they are apt to be intercalated. Inserted portion of spine, if any, not preserved.

There are three other species of this genus known. From *Gamphacanthus* (*Heteracanthus*) *politus* (Newberry) the present species differs in its much smaller size, asymmetrical shaft and bevelled anterior margin, as well as in the fewer and more wavy costae. From *Gamphacanthus* (*Heteracanthus*) *uddeni* Lindahl it differs likewise in its far smaller size, in the absence of the *Physonemus*-like hump observed in some specimens, its much more curved profile and asymmetrical shape, and its far less numerous costae. From both of the above species it differs in that the posterior sulcus extends almost if not quite to the apex of the spine.

There remains still another species, originally described under the name of *Onchus heterogyrus* by Agassiz, from the Devonian of Northwestern Russia. The type which has disappeared and another specimen in the British Museum of Natural History are fragmentary but bear the characteristic ornamentation of the genus. In size *Gamphacanthus heterogyrus* compares better with the present species—it is even smaller—but nothing is known of its shape and proportions except that the shaft appears to be straighter and rounder and the costae finer than in the species here described.

Newberry called attention to the absence of symmetry in these spines and to their reversed curve, making it almost certain that they were the defenses of the pectoral fins. I agree in this conclusion and would further remark that the worn condition of practically all specimens suggests that the fishes of this genus were bottom feeders, with habits of resting on their pectoral fins similar to the modern darters. However this may be I can see no valid reason for assigning these spines to the Chimaeroids as Eastman and others have suggested and my reasons for this have been given in another place ('18, p. 163).

I take pleasure in naming this species in honor of its discoverer.

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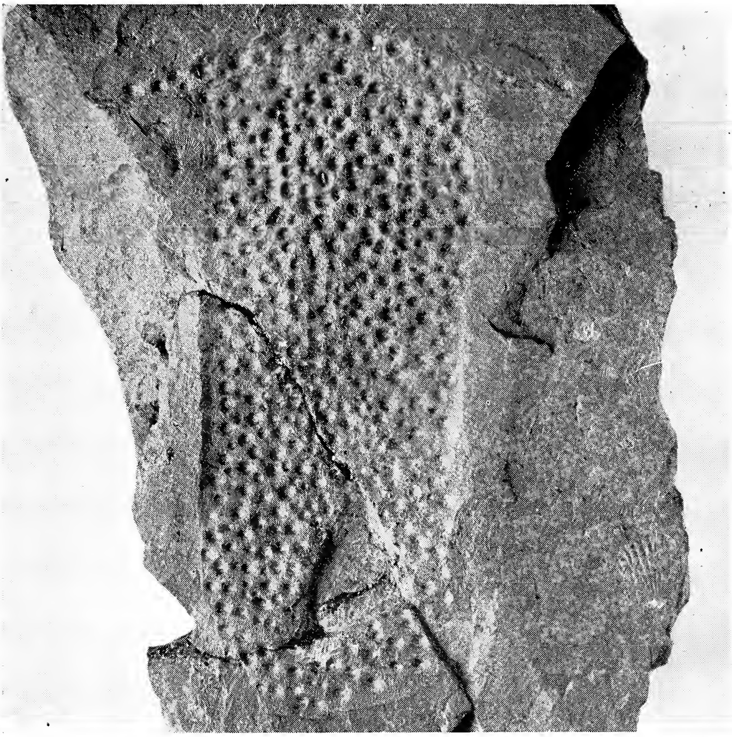


Figure 18 *Aspidichthys notabilis* W. Impression of antero-ventro median plate. x1

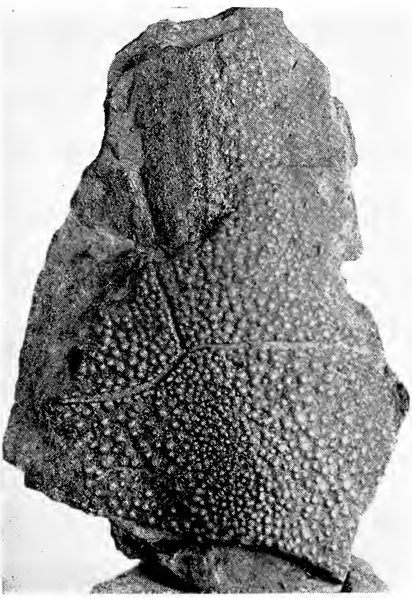


Figure 19 *Aspidichthys notabilis* W. Left post-orbital plate. x1

# A NEW COCCOSTEUS FROM THE PORTAGE SHALES OF WESTERN NEW YORK

BY

William L. Bryant

The recent fortunate discovery of a fossiliferous slab of black shale from the Upper Devonian shales of western New York has brought to light a new and remarkable species of the genus *Coccosteus.*

This type genus of the family Coccosteidae is rare in the United States, only a few fragmentary head shields and detached plates having ever been found. In Canada the famous Upper Devonian fish beds of Scaumenac bay, Quebec, have yielded some fairly well preserved examples of a single species.

The new find displays the head and fore trunk of a small fish. Although the cranium is badly crushed, the dentition is present; while the body armor exhibits the various plates in natural association and with diagrammatic clarity.

The slab of shale containing the remains exposed the visceral surface of the median bones of the head and body, as well as those of the right side. The bones of the left side and a part of the ventral armor must have remained attached to the counterpart, unfortunately missing. The front and sides of the head are badly crushed, leaving the marginal outlines uncertain.

The contours of the various bones were difficult to make out, due to overlapping on the visceral surface, and in places they were further confused by attached fragments from the left side. After making an enlarged photograph of the fossil in its original condition (figure 23), I determined to etch out the bone by acid, leaving a clear impression of the external surface in the matrix. That this method was successful may be seen by an inspection of the accompanying plates, while the figure herewith given, is a composite tracing from both views.

**Coccosteus angustus,** sp. nov.

**Type.** Head and trunk armor of a fish on black shale. New York State Museum no. *16004n.*

**Formation and locality.** Rhinestreet shale, (Portage), Silver Creek, New York.

The fossilized remains are those of a comparatively small fish measuring about 120 mm from snout to posterior tip of the dorso-

median plate. It was by far the most slender, laterally compressed and deep-bodied coccosteid of which we have any knowledge. The orbit was large, apparently somewhat elongated and more laterally directed than is usual in these fishes. The dorso-median shield is about three times as long as wide, while the posterior lateral plates are enormously developed. They meet the ventral armor below and form a long, boxlike carapace.

The head and body plates are ornamented with fine, stellate tubercules. Often on the side plates these tubercules occur only on the central portions while the remainder of the exposed surface is covered by a rugose ornamentation (figure 26).

In describing the dermal bones of this fish, I use the terms familiar to American paleontologists at the same time cautioning the reader that the names of the bones should not be understood as indicating that they can be directly compared with those of the Teleostomi. Recent investigations by Woodward and by Stensiö have shown that the nearest relations of the Arthrodires are to be found not among the Dipnoans but with the Elasmobranchs and that together with these they form a degenerating series with regard to the dermal skeleton.

**The dermal bones of the head.** Conspicuous upon the fossil as it was discovered was the left orbit (figure 23). Bounding this above and in front was the left preorbital plate, upon which may be seen the supraorbital sensory groove. The outer margin of the bone is fractured towards the rear and I believe that it may have bounded the orbit for a greater distance than is shown by my sketch (figure 20). The rostral element is missing, as is the small bone bounding the narial opening in front, while the pineal if present is so crushed that its outlines can not be traced. There are no traces of sclerotic plates to be seen.

Bounding the orbit below we see the narrow front arm of the suborbital plate, the expanded hinder end of which has entirely broken away.

The region of the postorbital is so badly crushed that nothing can be said as to the limits of that plate, but the paired centrals are present and have left a clear impression of their sculpture and sensory canal system in the matrix (figure 25). They are still united by suture and the number and course of the sensory canals and pit organs does not differ from those of typical coccosteids.

The supraorbital and median branch of the infraorbital sensory canals arise together at about the center of the plates and diverge forward and outward while the grooves for the middle and posterior lines of pit organs can be distinguished on each plate. The most

remarkable feature of the central plates is their comparatively small size, although I am not quite certain as to their outer boundaries.

The median occipital is conspicuous in the fossil. It is subquadrate in form, only a little wider than long, its hinder margin almost straight. It is well arched from side to side.

Only the posterior margin of the external occipital can be surely distinguished and I am in doubt as to its size and shape; and the boundaries of the marginal, too, are uncertain. Wedged between it and the central and adjacent to the external occipital is another bone which I take to be a part of the postorbital, but if it lies in normal position it is remarkable for its great length, occupying a position usually filled by the postero-lateral angle of the central. The bones in this region are so confused, however, that one can judge only of their limits by the direction of the radiating striae of the bone surface.

Just behind the mandible (figure 25), there lie two bones whose complete outlines can be distinguished. Each bears a few tubercules in the center from which an ornamentation of subparallel rugosities radiates to the margins. The larger (*X*, figure 20) is subquadrangular in outline, while the smaller (*Y*, figure 20) is heart-shaped. It would seem that neither of them can have any relation to the margin of the cranial roof proper since they are not apparently traversed by sensory canals. They resemble antero and postero ventro medians, but the ventral shield was apparently little disturbed. It is more probable that they represent the two cheekbones that are found behind the suborbital in certain species, that is, in *C. bickensis,* Van Koenen, and they agree well with these in comparative size, They are probably opercular elements.

In the snout region of the skull there are two bony fragments, one or both of which may be broken from the right preorbital.

**The dentition.** All six elements of the dentition are present, those of the left side lying above the right in each instance.

The premaxillas (figure 27, a) are comparatively wide and each terminates below in a single pronounced cusp. The maxillas are long and narrow. On the inner oral margin of the right maxilla I saw indications of a single row of small but worn and blunt teeth. While the elements of the upper jaw are shown in figure 23, they are not illuminated to the best advantage.

Of the mandibular (mixicoronoids of Stensio) elements, only that of the right side is complete, the other having lost most of the posterior, inserted portion, while the functional half is preserved (figure 25). There is no pronounced beak or fang at the anterior extremity of the mandible and no evidence of symphyseal or other denticles. The functional end is not thickened and demarcated from

the posterior spatulate process by a vertical shoulder, but there is, beneath the cutting blade, a pronounced horizontal shoulder especially on the outer surface. Beneath this the lower half of the front end of the mandible is quite thin and continues backward without perceptible demarcation into the broadened inserted end. The entire oral margin of the front half of the mandible consists of a bevelled and sharpened cutting blade with no indication of any groove or impression made by the cusp of the premaxillary. I assume,

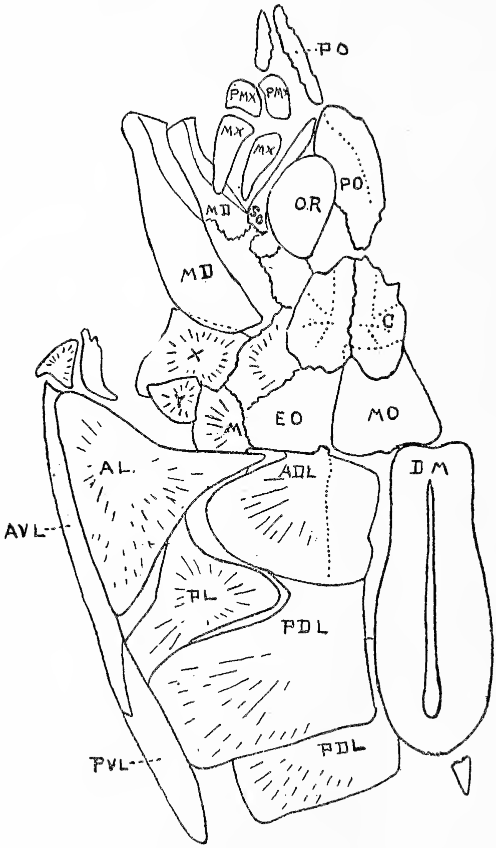



Figure 20 *Coccosteus angustus,* sp. nov. Head and fore-trunk in dorso-lateral view, X 1⅔. *A D L* Antero-dorso-lateral; *A L* Antero-lateral; *A V L* Antero-ventro-lateral; *C* Central; *D M* Dorso-median; *E O* External occipital; *M* Marginal; *M D* Mandible; *M O* Median occipital; *M X* Maxilla; *O R* Orbit; *P D L* Postero-dorso-lateral; *P L* Postero-lateral; *P M X* Premaxilla; *P O* Preorbital; *P V L* Postero-ventro-lateral; *S O* Suborbital; *X, Y* Plates of uncertain position, perhaps operculars. The lowest dotted line on the right central plate is not a sensory canal but indicates the top margin of the median occipital.

therefore, that this cusp passed outside of the front end of the mandible when the jaws were closed.

**The dermal armor of the trunk.** The dorso-median shield is proportionately longer and narrower than in any other species. It is vase-shaped rather than shield-shaped, with graceful outlines, and is much arched from side to side. It measures 56 mm in length, by 19 mm in greatest width and hence is about three times as long as broad. It is slightly emarginate in front, the anterior lateral angles rounded, and terminates behind in a spinelike process which has broken away in the present specimen. On the inner surface there is a longitudinal median keel which does not extend to either end of the shield. The plate is slightly shifted from its original position in relation to the median occipital. Like all the other upper median bones the plate is everywhere covered with fine stellate tubercules, there being no trace of the rugosities which ornament the side plates. I am unable to see the paired sensory canals which are usually found on this plate in other species.

The plates of the right side of the trunk lie closely attached in almost their normal relations to each other and their various outlines can be clearly seen. The right antero-dorso-lateral is still in contact with the head but has moved slightly from its original position. There is a well-developed articular condyle on the front margin, and the usual lateral line canal is seen to run directly backward from this condyle. Only the upper half of the plate is tuberculated, the remainder being ornamented by a network of fine anastomosing ridges which radiate more or less toward the margins.

Back of the antero-dorso-lateral is the enormous postero-dorso-lateral. This plate completely fills in the gap between the dorso-median and the postero-ventro-lateral, although it does not extend backward quite to the end of either plate. In this feature we again see a resemblance to conditions in *C. bickensis* Von Koenen, although in that species the postero-dorso-lateral falls short of meeting the ventral shield, while in the present fossil the trunk armor forms a complete boxlike carapace as in the Asterolepids. In front, this plate is in contact with the postero-lateral for the greater portion of its length. A portion of the left postero-dorso-lateral plate overlaid its mate of the opposite side and is seen (figure 20), projecting behind.

The antero-lateral is a large, triangular plate, thickened in front, and terminates above in a pointed process which fits into an excavation in the front margin of the antero-dorso-lateral. Below, it is in contact with the antero-ventro-lateral and behind, with the postero-lateral. The latter fills in the gap between the antero- and postero-dorso-laterals, the antero-lateral and the ventral shield.

In front of the extreme fore end of the antero-lateral (figure 27, b) may be seen one or two small bones. They are badly weathered, but I believe that at least one of them is comparable to the bone which Jaekel has called the angular in *Pholidosteus friedelii,* and which I have seen in other Coccosteids, especially in *Coccosteus canadensis,* where it is very much developed, its upper surface being excavated to receive the posterior blade of the mandible.

**The ventral shield.** Only the right margin of the ventral shield is preserved in the fossil, the remainder having apparently remained attached to the counterpart. The plates are little disturbed from their normal position and are still articulated together, appearing in the fossil almost as though seen in section. The antero-ventro-lateral is the longer of the two plates present. The postero-ventro-lateral extends past the postero-dorso-lateral to a point nearly beneath the tip of the dorso-median.

I have found no trace of a pectoral spine.

It seems to me that certain of the common ancestors of the Arthrodires and Elasmobranchs must once have been completely inclosed in a boxlike carapace in front, which, as these animals acquired carnivorous habits and mobility, became gradually reduced—a process only halted in the case of the Arthrodires by their sudden and complete extinction.

The Upper Devonian black shales of central and western New York so often considered barren of important fossils are gradually yielding a most interesting assemblage of fishes, conspicuous among which are the Arthrodires. As new light is thrown on these curious and aberrant forms, and as we become dimly aware of their true structure and affinities we recognize the importance of searching for more and better preserved material. The causes and modes of an evolution which could produce these armored fishes and the Elasmobranchs from a parent stock are unknown, and there is much in the structure of the Arthrodires of which we still have to learn.

This specimen was collected by E. R. Burmaster and donated to the New York State Museum.

Figure 21 *Gamphacanthus cooperi*, n. sp. Bryant. x4 (about).

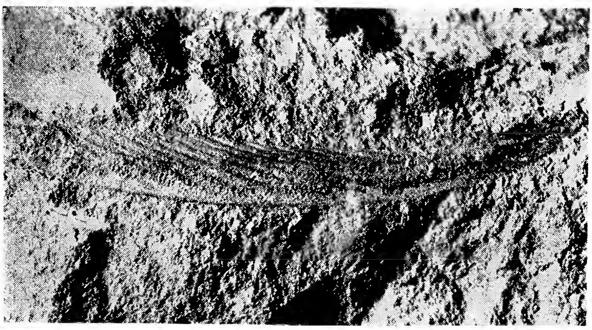


Figure 22 *Gyracanthus parvulus*, n. sp. Bryant. x2½

Figure 23 *Coccosteus angustus,* sp. nov. Head with dentition, and trunk armor showing dorsal shield and lateral plates of the right side in visceral aspect. X 1⅔

Figure 24 *Coccosteus angustus*, sp. nov. Impression in the matrix of head, dorsal shield and right lateral plates in outer view; the ventral shield shown only in section. X $1\frac{2}{3}$

Figure 25 *Coccosteus angustus*, sp. nov. Impression of right mandible and plates of the head and cheek; with front margin of lateral and antero-dorso-lateral. X 3

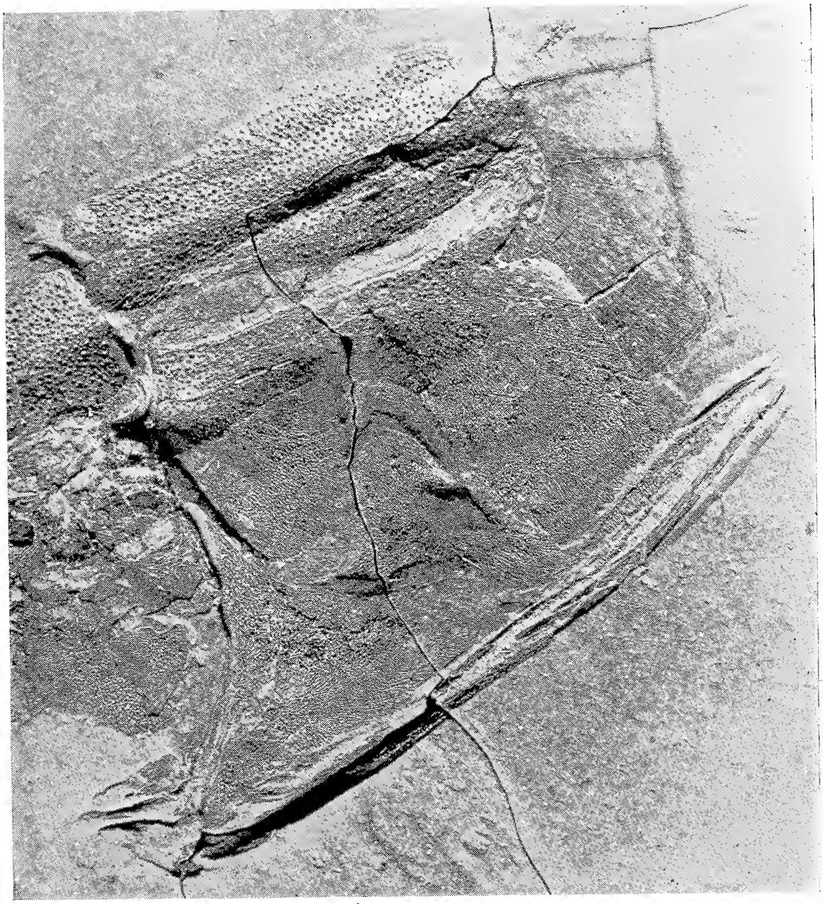
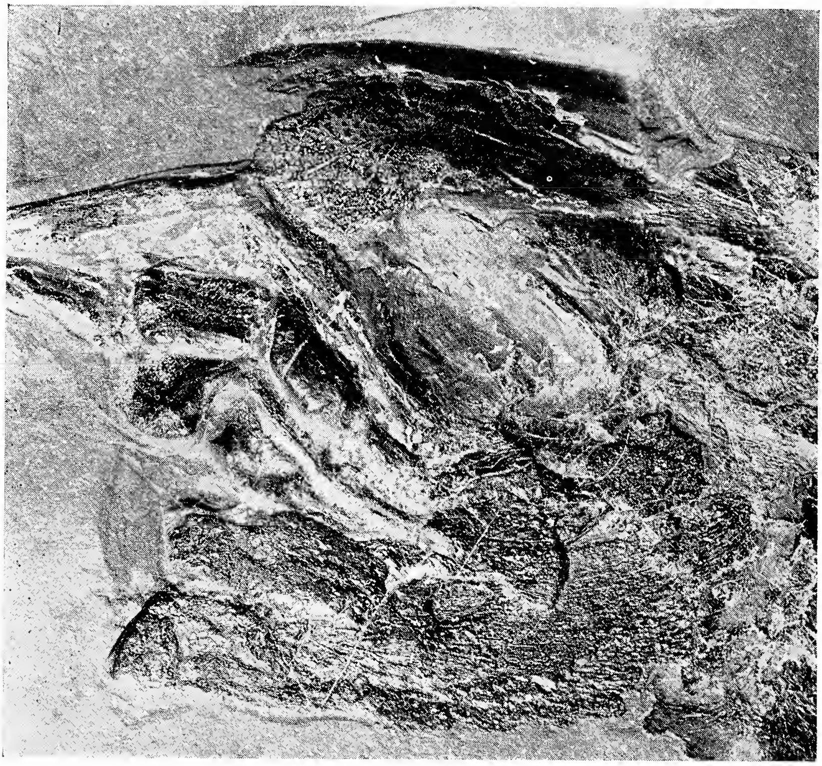
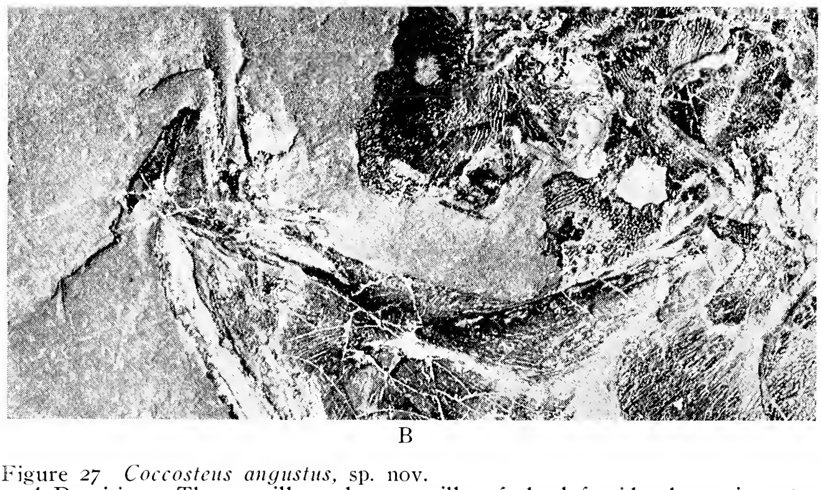


Figure 26 *Coccosteus angustus*, sp. nov. Trunk, showing dorsal shield and dermal plates of the right side. X 2



A



B

Figure 27 *Coccosteus angustus,* sp. nov.
*A* Dentition. The maxilla and premaxilla of the left side shown in outer view lie above those of the right side which appear in inner view. The maxillas are partly obscured by the matrix. Only the right mandible is intact. It is shown in inner view. X 2½
*B* Front margin of lateral, showing fragmentary plates at the antero-ventral angle. X 3

# NOTE ON OLDHAMIA (MURCHISONITES) OCCIDENS (WALCOTT)

BY

RUDOLF RUEDEMANN, PH.D.
*State Pateontologist, New York State Museum*

While engaged in the mapping of the capital district, the writer found in addition to the five localities of *Oldhamia occidens,* cited by Dale ('04, p. 13) as known to Walcott and him, another one on the slope east of the road halfway between Nassau village and Nassau pond. Unfortunately this locality which furnishes some beautifully distinct fossils is only a temporary one since cottages are now being erected on the site.

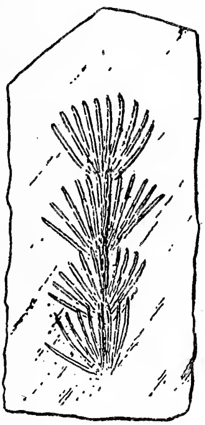


Figure 28 *Oldhamia occidens* (Walcott). Copy of original figure. Natural size.

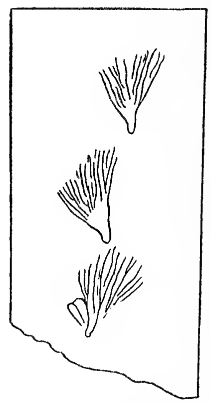


Figure 29 *Oldhamia occidens* (Walcott). Three tufts as found arranged on rock. Natural size.

As in the other localities, except the one in the Poestenkill gorge above Troy, N. Y., these fossils were found on the surface of a fine-grained quartzite bed, a little more than an inch thick and intercalated in greenish gray Lower Cambrian slate.

The material from this locality has afforded some observations that appear novel and important enough to record in this place.

The usual appearance of the form is that of a series of whorls of filaments, so closely arranged that the bases are not shown. Walcott ('95) in the original description considers the whorls connected by a flexuous stem. His description reads: "Frond with a jointed,

slightly flexuous stem; fan-shaped fronds, formed of numerous simple filaments or attached to the upper end of each joint; the filaments being somewhat longer than the joints and giving the entire frond the appearance of a succession of tufts of filaments, each springing from the summit of the tuft below."

In our material there are on one slab three whorls that though now separated, are still arranged in such a fashion that they appear to have become separated only shortly before entombment. These three tufts of whorls show each a distinct, more or less bulbous, well-rounded base, indicating an unmistakable articulation and giving the tufts a striking resemblance to dandelion seeds. While it would appear from Walcott's drawing that the supposed flexuous stems are but filaments of the whorls, it is also apparent that the bulbous bases are not long enough to have extended to the centers of the preceding whorls, when they were spaced as usually seen. It is therefore possible that there was still a small stem present.

Another feature that appears in our specimens and that has hitherto not been observed, is that the filaments were dichotomously branching. If it should turn out that the original material of *Oldhamia occidens* possesses strictly nonbranching filaments, the form from Nassau may prove a different species.

A third feature worth noting in our material is the presence of two club-shaped appendages (figure 32 at *a*) at the side of one of the tufts. These appendages though only preserved in one specimen, are distinct enough to invite speculation. If the fossil represents a fossil calcareous alga, it is conceivable that these appendages contained the conceptacles for the organs of sexual reproduction.

In one place (figure 32 at *b*) a well preserved carbonaceous filament, .1 mm wide, is seen in the middle of the wider casts of filaments.

We consider the observations here recorded as having an important bearing on the problem of the nature of Oldhamia.

Ever since that genus was erected by Forbes in 1848 for a fossil from the purple and green Cambrian slates of Bray Head in Ireland, it has been the subject of doubt and uncertainty, not only as to its taxonomic position, but even as to its reality as a fossil. Forbes considered it as belonging to the zoophytes or bryozoans, but later the German paleobotanists Kützing and Göppert, as well as Salter in England thought that they recognized algae in the two species *O. radiata* and *antiqua*. Also Schimper in the volume on Paleophytologie of Zittel's Handbuch der Palaeontologie refers the genus to the algae, creating a separate group, the *Oldhamieae*, for it and stating that they could not be graptolites since they show no traces of apertures and

the filaments are not articulated. He knows of no analogous living form.

F. Roemer, in the Lethaea palaeozoica ('80, p. 130) was apparently the first to deny the organic nature of *Oldhamia*. He bases his view on the apparently irregular arrangement of the parts, the absence of any organic matter on the fossils and the absence of other organisms in the rock. Sollas ('86) even found that the structure of *O. radiata* is not merely superficial but that it extends across the cleavage planes. Solms-Laubach, in his excellent and critical Fossil Botany ('91, p. 50) agrees with Roemer, adding that most observers consider Oldhamia as "the result of simple pressure or some similar purely mechanical cause, and that also Saporta must hold a similar view for he fails to cite *Oldhamia* as the oldest type of the class of

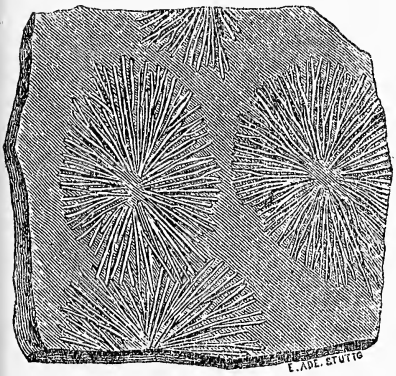



Figure 30 *Oldhamia radiata* Forbes Copy of original figure. x ½

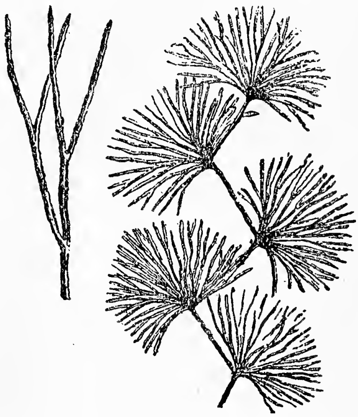


Figure 31 *Oldhamia antiqua* Forbes x ½ and enlarged branch. Original figure.

Algae." A. C. Seward, in his Fossil Plants ('98) also rejects *Oldhamia* as a fossil, holding that the pressure of the hand on a soft moist surface produces a raised pattern like a branched or delicate thallus. Also Potonié and Gothan in the Lehrbuch der Paläobotanik ('21) follow Roemer, adding that Roemer's view gains in probability of truth by the fact that O'Reilly has found *Oldhamia*-like markings in volcanic rocks in Ireland.

It thus seems that the consensus, of the paleobotanists at least, is that *Oldhamia* is to be rejected as a fossil plant. While we are not in a position to express any opinion on the British material from direct observation, we should still like to observe that it is generally *O. radiata* that is singled out as owing its origin to mechanical causes. *O. radiata* consists of irregularly scattered, disconnected bodies of

radiating wrinkles. These bodies may well be of purely mechanical origin. At the other hand, *O. antiqua* is described as consisting of fanlike groups of radii, which are connected in a series by a zig-zag axis. These bodies may well be of organic origin.

Our material agrees in its fanlike impressions of radii and the serial arrangement of the tufts with *O. antiqua.* So far as the material before me is concerned, I have not the least doubt, from all its surrounding conditions, that it is of organic origin.

The fossil consists of casts of such substantial nature that the organism which produced them must have been of quite resistant nature, such as calcareous algae would supply. It appears that the casts are on the undersurface of the thin quartzite beds, corresponding to depressions in the underlying argillaceous mud. In the case of calcareous algae, it is quite probable that the calcareous substance was dissolved, as it usually is, in a sedimentary deposit that is as free from calcareous admixture as the Cambrian green shale and quartzite are. The siliceous layer, being deposited on the green mud, then gradually filled the depressions being produced by the slow dissolution of the fronds of the calcareous algae. On one slab the filaments are seen as grooves, which are the original molds left by the fronds.

As to the taxonomic position, I feel with Walcott that "the suggestion that it is a calcareous alga appears to be as satisfactory as any." The articulated structure, the dichotomous branching, the presence of a carbonaceous central film, the club-shaped appendages, representing possible sexual conceptacles, and the mode of preservation (casts of substantial bodies) all unite to point to such organisms. It may be added that probably the filaments were also segmented, and that suggestions of segmentation may be seen in some specimens (not sufficient, however, to prove it) on the filaments.

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Figure 32 Enlargement (about 3½) of the tufts to show branching and bases. *a* Club-shaped appendages; *b* Carbonaceous filament.

# GRANITE PHACOLITHS AND THEIR CONTACT ZONES IN THE NORTHWEST ADIRONDACKS

BY

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## INTRODUCTION

This paper is based upon five summers' field work in the northwest Adirondacks, of which four were spent in mapping the areal geology of the Lake Bonaparte, Lowville, Hammond and Antwerp quadrangles.

In 1916, while the writer was working on the Lake Bonaparte quadrangle, the peculiar structural features of the California granite mass suggested a laccolithic or phacolithic body; but since nothing of this sort was known in the northwest Adirondacks, it was referred to as a batholith in the report on that area.

Most of the summer of 1917 was spent in a study of the pyrite deposits of St Lawrence and Jefferson counties; and in connection with this work, the writer made a general reconnaissance of the whole Grenville belt of the northwest Adirondacks and became aware of the existence of numerous oval-shaped granite bodies with structural characters similar to those of the California mass.

A study of four such masses on the Hammond quadrangle in 1921 and 1927 led the writer to the belief that they were phacoliths; and in 1928 he spent a month in a reconnaissance of the whole problem, aided by an appropriation from the research funds of the department of geology of Princeton University. The problem is a large one, and the present paper can present only a rough survey of some of the more salient features.

The writer wishes to acknowledge his debt for aid in interpreting the geology, to the writings of present and former workers in this region, particularly to H. P. Cushing, J. C. Martin, W. J. Miller, D. H. Newland and C. H. Smyth jr. He has also had the benefit of discussion with Professor Smyth of the problems considered in this paper.

The conclusions which the writer has drawn in this report are summarized herewith.

In the foothill belt of the northwest Adirondack province, lying southeast of the St Lawrence river and parallel to it, there is a belt of Grenville formations, with associated intrusive igneous rocks, exposed

for a length of 60 miles and a width of 30 miles. Fourteen elongate granite masses, from two to more than 15 miles in length, are known in this belt, have been studied by the writer and are interpreted as phacoliths resulting from intrusion of magma in the crests of anticlinal folds and subsequent intense deformation by continued folding before the magma's complete consolidation. This interpretation is based upon the restriction of the granite bodies to anticlinal folds; upon the general conformity between the borders of the granite mass and the bedding of the country rock, both on the limbs and on the plunging noses of folds; upon the actual exposure of the base of a

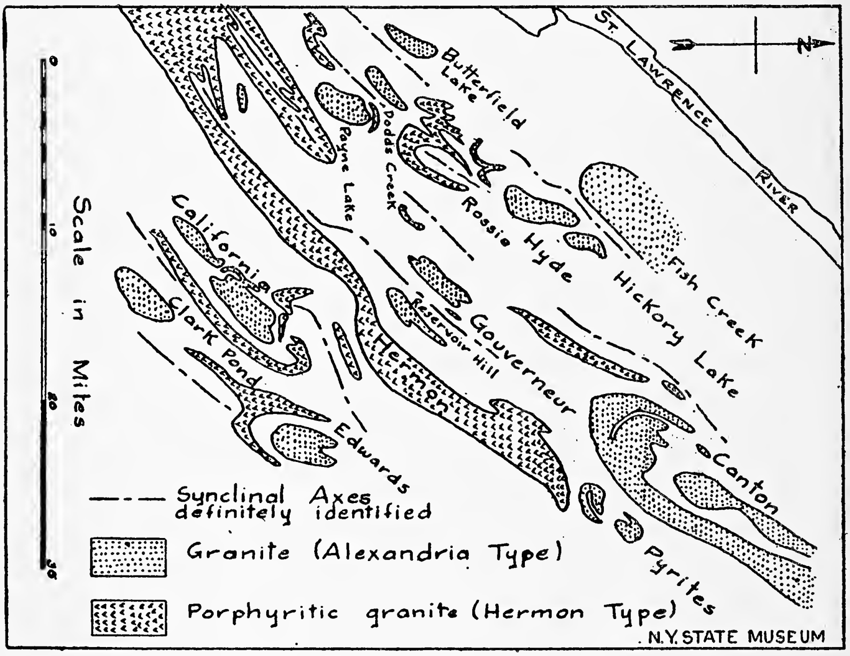



Figure 33 Map showing location of granite phacoliths and folded (?) sills in the Grenville belt of the northwest Adirondacks. Granite phacoliths (Alexandria type) are all on anticlinal axes.

major phacolith; and upon contemporaneity of folding and intrusion, as indicated by phenomena connected with the foliation and texture of crystallization. The inclosing folds of the Grenville are isoclinal and either vertical or overturned, with a uniform dip as low as 30° NW, and pitch often 30° or more and locally as steep as 70°.

A porphyritic type of granite has the structural relations of intrusive sheets, and there are some indications that it may be slightly older than the granite phacoliths and may have been folded along with the

inclosing Grenville beds as have a series of older gabbro, diorite, quartz diorite and monzonite sills.

The structure of the northwest Adirondacks is interpreted as essentially the result of the interplay of thrusts due to magmatic intrusion and of deformation as though by two contemporaneous orogenic forces, the major one acting along NW-SE lines, the minor one about at right angles. The pressure exerted by the magma is in turn believed to arise from the orogenic forces.

The foliation and bedding in the Grenville formations are uniformly parallel. This is interpreted as resulting from deformation of a system partly solid (Grenville) and partly liquid (magma and magmatic solutions), and is not necessarily the result of load or static metamorphism, as so commonly inferred.

The structural phenomena of the great granite-monzonite mass of the Adirondacks are briefly reviewed and interpreted in the light of the conclusions derived from a study of the intrusions in the Grenville belt of the northwest Adirondacks. Much evidence is found that it is in considerable part a composite body of sill, sheet, phacolithic and laccolithic masses with a minor amount of included belts of Grenville with associated dikes in various degrees of deformation, and of considerable age difference, although probably belonging to the same magmatic period.

As indicated, there are two well-defined lithologic types of granite in the Grenville belt of the northwest Adirondacks. One, here referred to as the Hermon type, is a porphyritic coarse-grained rock, with coarse to medium equigranular chilled facies, and occurs characteristically as relatively long, narrow sheets parallel to the bedding of the country rock and perhaps folded with it. It possesses normally a well-developed foliation but cataclastic structures are rarely found. This intrusive has locally developed dark hornblende and pyroxene gneisses from limestone, but is nowhere known to have developed garnet-sillimanite contact facies.

The other type (called Laurentian by Cushing, here referred to as the Alexandria type) is nonporphyritic, of fine to medium grain, often with an alaskitic character and the appearance of an aplite. The rock is somewhat variable; but an average specimen may consist of about 51 per cent microperthite, 35 per cent quartz, 12 per cent oligoclase, with 1 to 2 per cent of accessory minerals, such as biotite, magnetite, hornblende, pyroxene, apatite and rare zircons. Another facies consists of about 40 per cent orthoclase or microcline, 26 per cent oligoclase, 32 per cent quartz and the usual accessory minerals. Hornblende and pyroxene are present only where the granite is con-

taminated as a result of disintegration of hornblende or pyroxene gneiss layers.

The fine to medium-grained granite (Alexandria type) occurs in several different ways. In the main body of the Adirondack Mountains it forms large belts with uncertain structural history. Within the belt of the northwest Adirondacks, underlain largely by the Grenville series, the granite of this type forms small oval to irregular equidimensional bodies from two to more than 15 miles in length, and has a phacolithic structure. The area in which the phacoliths occur is shown on the Canton, Russel, Gouverneur, Lake Bonaparte, Hammond, Brier Hill, Ogdensburg and Antwerp United States Geological Survey topographic sheets. They are shown in figure 33. The phacoliths are not restricted to any horizon, but occur throughout the whole Grenville series. Within the hard frangible Grenville gneisses and quartzites, the granite usually has abundant included long, narrow bands of country rock. The structural relations here are not easily made out, for the bedding and foliation dip steeply and there is much brecciation and disturbance of the country rock. In many cases granite grades into gneiss and gneiss into granite, and boundary lines are blurred and indistinct.

Within the pliable plastic crystalline limestone the structure of the granite masses is better shown, and in several cases well shown. Eleven such granite masses in the limestone have been studied by the writer. Some are poorly exposed, particularly along the borders. Four have been chosen to be figured and described in detail because they best show the variations in the phacolithic structure and the contact zones.

A few narrow (none over 1500 feet wide) aplite sills are found, in direct genetic connection with the phacoliths as subsidiary intrusions. They may occur both in the gneisses, quartzites and limestone. Sills of aplitic granite are rarely found independent of the phacoliths, though they do occur.

Along much of the contact between the granite (Alexandria type) masses and the limestone country rock, there is a narrow zone up to 150 feet in width that consists of hornblende or pyroxene gneiss, intrusive sills of granite, sheets of garnet-sillimanite gneiss and dikes and lenses of pegmatite. The hornblende and pyroxene gneiss layers are interpreted as limestone layers metasomatically replaced through the action of volatile compounds or by residual solutions during the consolidation of the granite. The origin of the garnet-sillimanite gneiss presents many puzzling features, but it is suggested that it originated in part from the combined effect of the destruction of amphibolite layers and of the concentration and precipitation of relatively volatile com-

pounds of ferrous iron, alumina, soda, magnesia and titanium locally in the border portion of the main magma body; and in part from pegmatitic solutions injecting, reacting with, and replacing amphibolite layers.

The Grenville rocks have all been completely recrystallized and, except for local belts, so injected or permeated by pegmatitic solutions that they are now injection gneisses, mixed rocks or migmatites. Usually there are everywhere more or less pegmatite lenses and vein-

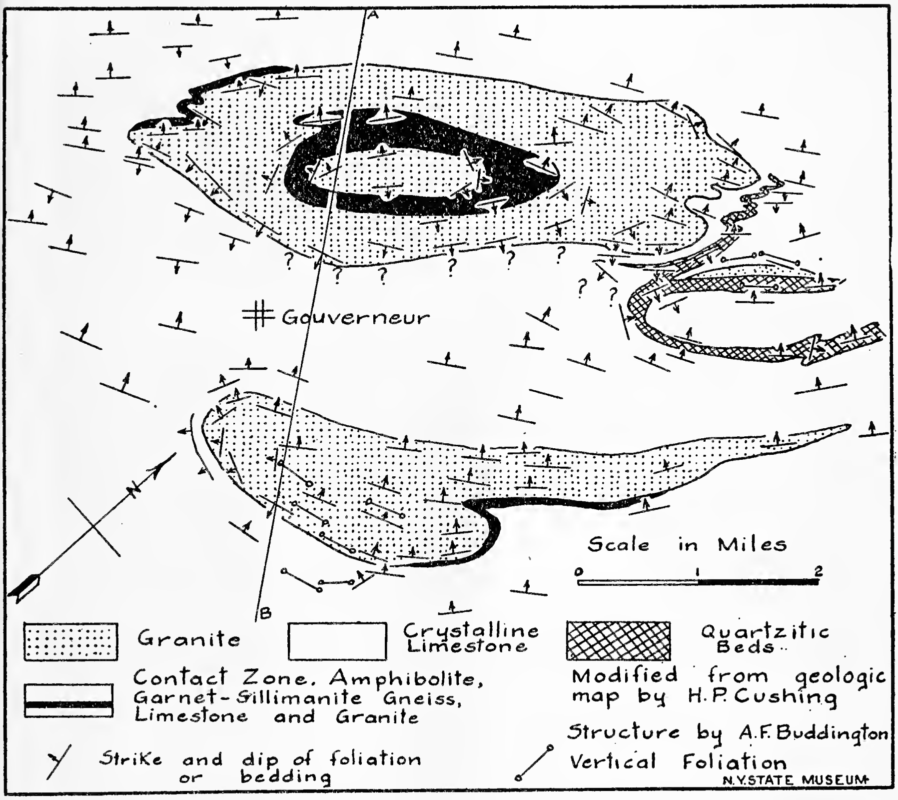



Figure 34 Gouverneur and Reservoir Hill phacoliths, Gouverneur quadrangle.

lets of simple composition in the Grenville formations. These are connected with both types of granite, and no means of discrimination as to which belongs with which, except that of geographic association, has yet been found. In the limestone there is locally much veining by quartz, and there are all gradations in degree of replacement between pegmatite lenses and fairly clean limestone.

## GOUVERNEUR AND RESERVOIR HILL PHACOLITHS

The Gouverneur granite mass lies just northwest of the town of Gouverneur, and the Reservoir Hill body just southeast of Gouverneur. Both are shown on the geological map by Cushing. (Cushing and Newland '25). A modified copy of Cushing's map, with the structure inserted by the author, is shown in figure 34.

The Gouverneur phacolith will be described first. It is about five and one-half miles long and one and one-half miles wide, and is

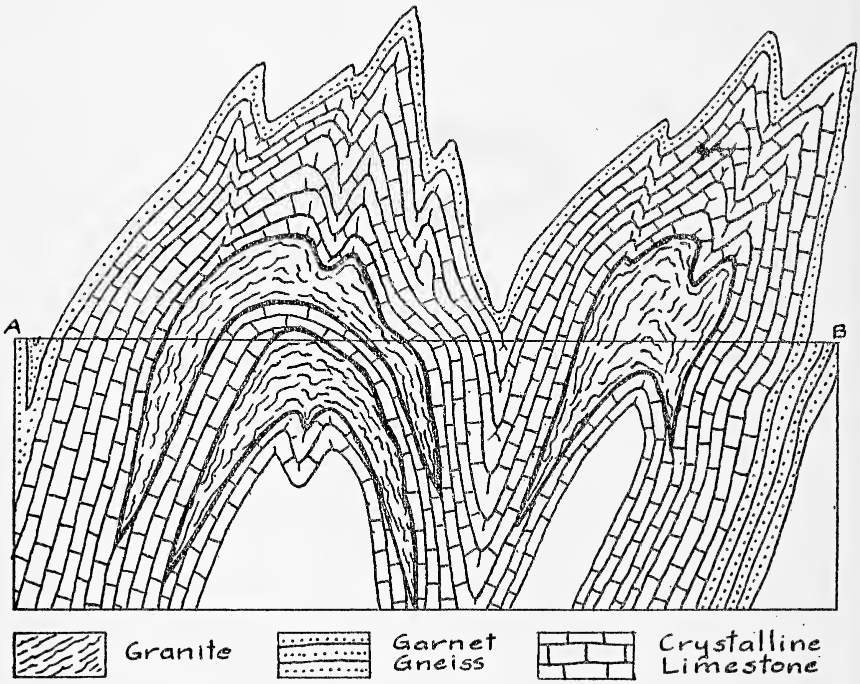



Figure 35 Inferred structure section across Gouverneur and Reservoir Hill phacoliths along line A-B

mapped by Cushing as a body of Laurentian granite, which he refers to as a sill, stating that it has no domical foliation. Detailed work by the writer shows that this body does have a domical foliation and conforms in character to a phacolith. The granite is intrusive into, and is wholly inclosed in, limestone. Quartzitic beds, in part thinly interleaved with limestone, occur near the granite at the northeast end. The structure here is very complicated, and most of the critical areas are covered with glacial drift or stratified deposits. The mapping is therefore somewhat hypothetical. Cushing states that the granite crosscuts the Grenville formations along the southeast side.

The writer could find no positive evidence of this, due to lack of outcrops. There is very probably some crosscutting of the Grenville by the granite, but the writer believes that it is not of a character, or sufficient in amount, to vitiate the hypothesis of general phacolithic intrusion.

The granite mass is interpreted as a compound phacolith (figure 35) consisting of two shells of granite with an intervening zone of interbanded limestone, amphibolite, biotitic plagioclase gneiss, granite and pegmatite veins, with garnet-sillimanite gneiss along the upper and lower contacts. The limestone beds within the intergranite Grenville band are well exposed along the west limb but, if present on the east limb, are covered. The outer shell of granite is about 700 to 800 feet thick on the southeast limb and somewhat thicker on the northwest limb. The intermediate zone of interbanded Grenville metamorphics and intrusives is about 500 to 700 feet thick. (Shown in figure as a contact zone.) The base of the inner shell of granite is not exposed. The phacolith is thicker along the axis where it plunges than on the limbs.

The axis of the phacolith, about one-fourth of its length from the northeast end, takes a sharp bend from the prevailing northeast strike and trends east-northeast. The northeast end of the dome is thus asymmetrical, and the foliation strikes uniformly east-northeast where it might normally be expected to box the compass if the swinging of the axis is not taken into account. At the extreme southwest tip, the dip is uniformly 60°–70° NW due to overturning, but in the core true domical foliation is characteristic. On crossing the core at right angles to the elongation of the dome, every step from a steep northwest dip through horizontal foliation to a moderate southeast dip can be plainly observed. The elliptical belt of altered Grenville formation is well shown by a topographic depression surrounded by a low infacing scarp.

The reentrants at each end of the mass are due to minor folds pitching northeast and southwest respectively at the opposite ends. At the northeast end this is especially well shown, the anticlinal and synclinal structures being readily worked out in the adjacent limestones.

The core of the phacolith for a length of three and one-half miles thus has a normal domical character with a gentle dip to the foliation and included gneiss layers on the southeast limb varying from 15° to 30°, a somewhat steeper but moderate dip on the northwest limb, and flat-lying in the relatively broad axial portion, pitching from the center gently to the northeast and southwest. Each end is over-

turned to the southeast so that isoclinal foliation is characteristic there.

The granite, when examined in thin section, shows a fabric varying from seriate homeoid to seriate intersertal, usually seriate porphyroid. The texture is similar to the granulitic character of an aplite, and there is practically neither protoclastic nor cataclastic structure shown.

A contact zone consisting of interbanded garnet-sillimanite gneiss, granite, pyroxene and hornblende gneisses, and pegmatite is well exposed along the upper contact of the shell of Grenville which separates the two portions of the compound phacolith. Another similar zone is exposed at intervals along the lower contact. Along the upper contact it can be traced for a length of three and one-half miles. It was not noted along the southwest end, where it may be absent, covered, or may have been overlooked. It is well exposed at the north end of the belt, just to the west of the axis. Here there is about 100 feet of uniform garnet-sillimanite gneiss, overlain by a zone of granite with many narrow bands of dark ferromagnesian gneiss. The garnet rock is cut by many large and small pegmatite veins, most of them carrying tourmaline. Locally the garnet rock and the pegmatite are slightly impregnated with pyrite. About one and one-half miles southwest there is a 20-foot band of garnet-sillimanite gneiss, with limestone exposed in the footwall. Locally layers of garnet rock a few inches thick are found in the limestone with narrow contact zones developed.

The garnet-sillimanite gneiss consists of 25 per cent to 40 per cent garnet, and quartz, microcline, microperthite, plagioclase and sillimanite as the major minerals, with biotite, ilmenite and locally graphite as accessory minerals. It is often veined with thin quartz seams parallel to the foliation.

The only band of contact rock observed in the outer border of the phacolith is that along the northwest side of the southwest end, where it parallels the curve of the boundary for a length of about a mile and a half, intervening between the granite and the limestone. This consists of garnet gneiss and of granite with many layers rich in ferromagnesian mineral. The garnet rock has the appearance of a mixed rock, originating through the shredding, disintegration, alteration and replacement of pyroxene gneiss and amphibolite layers by pegmatite vein-forming solutions. The pyroxenic bands had evidently been partly changed to hornblende and biotite schists before their transformation to garnet gneiss, for bands of such character occur prominently in the adjoining granite. The garnet gneiss has a splotchy appearance with abundant minute lenticles richer in ferromagnesian minerals, or it has a definite injection gneiss structure. At no place

examined was it more than 20 feet thick. The major minerals are garnet, microcline, plagioclase, sillimanite and quartz, with a very little hornblende or biotite and accessory magnetite and apatite. In some of the rock sillimanite is absent and there is considerable biotite instead. The plagioclase is locally almost wholly replaced by scapolite, and the garnet is also flecked with the same mineral. The biotite and plagioclase both appear to be eating into and replacing the sillimanite. Lenses of fresh black enstatite-hornblende gneiss also occur within the garnetiferous gneiss. The hornblende is in part, and perhaps in whole, secondary after the enstatite.

The limestone around the southwest end of the Gouverneur phacolith, and for a couple of miles beyond the phacolith to the southwest, contains a number of pegmatite lenses which are oriented with direct relation to the phacolith and its probable underground extension.

Between the Gouverneur and Reservoir Hill granite masses lies a belt of limestone with practically uniformly steep (70°–80° W) or vertical dips, except locally in a belt three to four miles northeast of Gouverneur, southwest of the old Cole pyrite mine, where the writer has found an open synclinal structure. This syncline is very well outlined by a belt of white quartzite, thin banded with white pyroxene and tremolitic layers, which may be used as a key horizon. This belt can be traced southwest to a point about three-fourths of a mile northeast of Dodds School, where it describes an arc and turns northeast again, striking toward the band of rusty gneiss at Cole, which appears to represent the southeast limb. Cushing's map is generalized for this vicinity and does not show this fold. Evidences of this fold are also indicated by the strikes and dips shown by Cushing near Gouverneur, and the writer has traced its extension southwest on the Hammond quadrangle. The structure between the two granite masses is therefore definitely indicated as a closely compressed syncline with nearly vertical dips except for local areas. Locally opposed dips indicate small drag folds.

The Reservoir Hill mass lies just east of the town of Gouverneur and is shown on the geologic map by Cushing, where it is mapped as a member of the porphyritic granite (Hermon type) bodies. The writer believes that this mass positively belongs with the fine to medium even-grained granites, (Alexandria type) because it nowhere shows a porphyritic texture, it has developed locally, against limestone, the usual narrow contact zone with associated garnet rock, it carries magnetite-bearing pegmatites, and it has the structural relations characteristic of the granite masses of this kind. Cushing called the mass a sill. At the southwest end the limestone can be traced almost continuously around the blunt end of the granite that holds in-

closed pyroxene gneiss layers, the foliation of the latter conforming in detail, the structure passing from a northeast strike and northwest dip through an east-west strike and vertical dip back again to a northeast strike and northwest dip, as one goes from the southeast side around the end to the northwest side, exactly as is required for an overturned fold. No evidence whatever could be found that the limestone split so that adjacent beds passed, one on one side of the granite and the other on the other side, as would necessarily be the case if this were a sill. The foliation is likewise continuous as one complete curve around the end. The complete curving of the foliation and of the pyroxenic gneiss layers through an angle of 180° may be seen anywhere within a belt five eighths of a mile from the southwest end. Northeast of this the fold is much tighter and the foliation dips practically uniformly 70°–80° NW.

At the southwest end of the mass there is a splendid example of how the amphibolite layers have been affected by the major NW-SE pressures. Where the layers strike parallel to the major stress, they are crumpled back on themselves in symmetrical folds with an amplitude of several feet; as the layers become successively more nearly at right angles to the stress, the folds become asymmetrical, grow smaller and smaller and dwindle to mere crinkles, until finally, where the layers are at right angles to the major stress, only groovings produced by the minor component of stress show in the plane of the dip.

When examined in thin section, except near the borders of the mass, the granite has a seriate homeoid pattern with perfect interlocking texture of crystallization. Along the borders the fabric is seriate porphyroid, with a texture due to crystallization from a magma. Not a trace of cataclastic structure was seen in any of the sections examined, and practically no protoclastic structure.

On the east side of the mass, for a length of about three miles, Cushing has mapped a band of garnet rock with associated amphibolite, which he ascribes to contact metamorphic origin. It is best shown in the vicinity of the reentrant. His description (Cushing and Newland '25 p. 33) is as follows:

Garnet gneiss, which is unmistakably of contact origin, is found adjacent to some of the granite of the quadrangle. Such rock is best and most persistently shown along the east and southeast margin of the granite of the Reservoir Hill sill, east of Gouverneur. The zone of contact rock is very narrow, in general from one to five feet in width, lying between granite and the adjacent limestone. Along a portion of the east margin it widens considerably, but even here it can not be mapped without exaggeration.

A narrow sill, several inches wide, in limestone from this garnet zone was examined by the writer and found to consist of garnet,

plagioclase, quartz, and biotite, with accessory magnetite, apatite, zircon and calcite. Cushing mentions also the presence of pyroxene, tourmaline, and pyrite.

Cushing gives the following description of a border facies of the granite:

At the southwest end of the sill, where it plunges down under the limestone, the extreme upper edge of the granite is of green color and greatly resembles the ordinary green syenite of the Adirondack region. It also contains both the peculiar green pyroxene and the bronzite and allanite.

This rock is not a syenite, however, but a plagioclase rich facies of the granite which often develops locally at the border.

## CALIFORNIA PHACOLITH

The general characters of this body of granite and its contact aureole have been previously described by Smyth and Buddington ('26, p. 81–85). The writer has since restudied the mass, mapped its extension on the Antwerp quadrangle, and made additional petrographic studies. The relations of the contact zones to the granite masses are shown in figure 36, where the width of the contact band is much exaggerated to bring out the relation and a hypothetical cross section to show the writer's present interpretation of the structure is given in figure 37.

The California body of granite, as it is exposed at the surface, comprises two separate major masses and two sills; but the separation into two large masses is regarded as a purely superficial phenomenon,

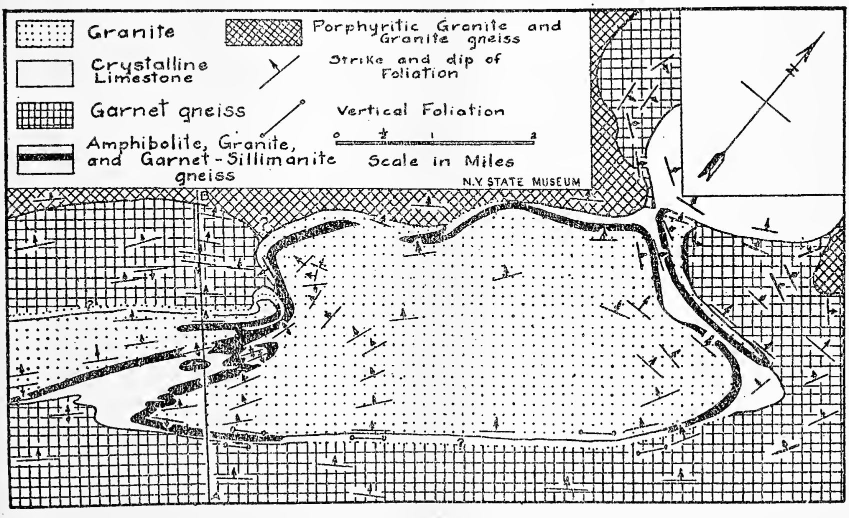



Figure 36 California phacolith, Lake Bonaparte quadrangle.

and the whole mass is regarded as a phacolith. Except near the borders the foliation of both masses and of the sills dips quite uniformly 30°–35° NW, and anticlinal structures are shown only at the borders and within a mile or two of the ends.

At the southwest end of the larger area, for a length of two miles in a north-south direction, there is a great series of minor folds or crumples in the foliation of the mass plunging gently southwest, with locally a thin layer of limestone resting on the granite in the troughs. At the extreme southern tip, the anticlinal structure is particularly well shown where the limestone and contact zone can be traced continuously around the nose and over the top. It is these folds which give the crenulate character to the southwestern border.

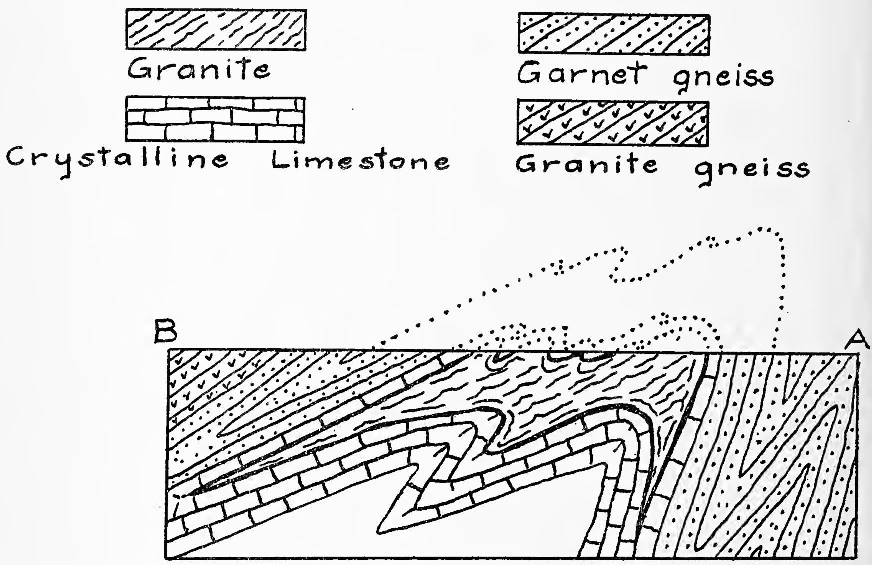



Figure 37 Hypothetical structure section of California phacolith along line A-B

About three-fourths of a mile north of the southwestern tip of the larger granite mass, the top of the phacolith is still only incompletely exposed by erosion, and there are alternating exposures of normal granite and of the contact zone of interbanded garnetiferous and dark ferromagnesian gneisses. Within the northern portion of the major mass the dip of the foliation is 40°–45° N, and for a narrow zone along the southeast side it is vertical to steep NW, conforming to that of the adjoining gneisses.

Except for three gaps where the border zone of the phacolith is covered for some distance, the interbanded garnet-sillimanite gneiss,

pegmatite, and pyroxene gneiss or amphibolite may be traced, by intermittent outcrops, around the border of the main body of the granite mass. Along the western and northern borders of the granite, limestone is the only country rock exposed adjacent to the contact aureole. On the southeastern border the granite is adjoined by a belt of biotite-garnet injection gneiss, though it is probable that a narrow band of limestone intervenes between the granite and the gneiss. At one place on the northern border, it looks as though the granite must come directly against limestone, without any intervening contact zone.

The limestone which immediately overlies the garnet rock at the south end of the California mass consists of bands of limestone with only a few silicates, alternating with bands carrying quantities of disseminated silicates. The latter consist predominantly of serpentine pseudomorphous after pyroxene, with a little associated phlogopite and spinel. Scapolite nodules are also present.

In general, narrow bands of the dark gneisses occur here and there within the core of the granite masses, but they are much more abundant closely adjacent to the contact with the limestone. In the dark gneisses the ferromagnesian minerals may be enstatite alone; enstatite, monoclinic pyroxene and hornblende; monoclinic pyroxene and hornblende; or hornblende alone. The plagioclase is often partly or wholly altered to scapolite. Much of the granite associated with the ferromagnesian gneisses is greenish, and consists of quartz and plagioclase with varying amounts of microperthite and relics of unreplaced enstatite, monoclinic pyroxene, or hornblende. There is a tendency for a zone of the black gneisses, with more or less injected granitic matter, to occur between the limestone and garnet-sillimanite gneiss zone. No gradual transition between the rocks of the contact aureole and the limestone, or between garnet-sillimanite gneiss and granite or the ferromagnesian gneisses has been observed. The contacts are sharp. Tourmaline is a common constituent of the pegmatite dikes and rarely garnet. Thin quartz veinlets are common in the rocks of the contact zone parallel to the foliation.

A typical band of the contact zone is exposed at the northeast end of the major granite mass, where the following sections were noted:

| *Feet* | *Rock* |
|---|---|
| 60 | Garnet-sillimanite gneiss |
| 30 | Pyroxenic gneiss |
| 40 | Garnet-sillimanite gneiss |
| 15 | Medium-grained greenish granite, with several thin bands of garnetiferous rock averaging about six inches thick |
| 50 | Medium-grained greenish granite with schlieren of black pyroxenic gneiss |
| Core | Normal fine-grained pink granite |

The major minerals of a specimen of the garnet-sillimanite rock are garnet, sillimanite, microperthite and quartz, with accessory ilmenite and apatite.

The major minerals of the pyroxenic gneiss are plagioclase, monoclinic pyroxene, enstatite and greenish brown hornblende. Accessory minerals include biotite, magnetite, apatite, and rarely a trace of garnet or tourmaline. Locally the plagioclase is partially replaced by scapolite, and secondary quartz has been introduced. The monoclinic pyroxene, enstatite and hornblende are to a considerable extent each the predominant ferromagnesian mineral in alternating very thin layers, the pyroxenic layers being much more abundant. The brown hornblende is primary. The biotite is probably secondary, and in part replaces the pyroxene.

A thin section of the greenish granite shows it to consist of the major minerals orthoclase, plagioclase, and quartz, with grains of enstatite scattered through certain thin bands as a result of the disintegration of pyroxenic gneiss. Accessory minerals are apatite, magnetite, and zircon.

The smaller granite mass is forested, and critical zones are covered or difficult to find; but an aureole of garnet rock is similarly traced around the northern end, except along a portion of the west side, where it has not been traced and where garnetiferous injection gneisses border it on the west. The garnetiferous contact facies of the granite has also been traced as a narrow band along the south side of the northern sill. In all these cases, so far as has been ascertained, the garnet-bearing granite facies and the pyroxenic gneisses have been developed where limestone has been observed or inferred to be the country rock. On the west side of the limestone area, which separates the two main bodies of granite, a small lens of garnet rock is shown on the sketch map extending out into the limestone. There is a small hill here composed of garnet rock and dark injection gneiss formed by a flat-lying sill of granite in limestone.

There are two types of garnetiferous rock in the aureole of the California granite mass. In one type the major minerals are almandite, plagioclase, quartz and biotite. Microperthite is as abundant as plagioclase in some of the rock, and only an accessory in much of it. A trace of deep green spinel occurs as inclusions in the garnet in a number of specimens of this type, or as a thin meshwork inclosing grains of plagioclase, or as irregular shaped grains in association with plagioclase. Ilmenite, apatite, zircon and allanite are accessory minerals. Crystalline flake graphite occurs in a few specimens.

In the other type the major minerals are almandite, microperthite, plagioclase, sillimanite and quartz. Microperthite is usually predominant over plagioclase. Accessory minerals are green spinel, ilmenite, apatite, zircon and allanite. A trace of corundum was found in one specimen. A little biotite often occurs as a secondary mineral along cracks in garnet.

One exceptional type consists of microperthite, quartz, garnet and a very little biotite, with accessory plagioclase and sillimanite; but in this specimen the sillimanite is inclosed in garnet and in plagioclase, and thus not in contact with biotite.

In typical rocks biotite and sillimanite are mutually exclusive; plagioclase is the predominant feldspar in the biotitic facies, and microperthite in the sillimanitic facies. The almandite usually occurs as skeletal grains.

Garnet, for chemical analysis, was separated by hand picking from a representative specimen of the garnet-sillimanite facies of the granite at the north end of the California mass. The garnets are in part of skeletal character; and small inclusions of quartz, magnetite, ilmenite and a trace of plagioclase were unavoidably included in the sample. The writer is indebted to Professor A. H. Phillips for the chemical analysis. The garnet is an almandite with a considerable percentage of the pyrope molecule.

*Almandite from Almandite-sillimanite Granite*[1]

| | |
|---|---|
| $SiO_2$ | 41.79 |
| $Al_2O_3$ | 19.07 |
| $Fe_2O_3$ | 2.11 |
| FeO | 28.10 |
| MgO | 5.15 |
| CaO | 1.89 |
| $TiO_2$ | 1.70 |
| MnO | .51 |
| | 100.32 |
| Almandite | 59.20 |
| Pyrope | 17.28 |
| Grossularite | 4.95 |
| Spessartite | 1.00 |
| Ilmenite, Magnetite, Sillimanite and Quartz | 17.84 |

[1]Analyst, A. H. Phillips.

## CANTON PHACOLITHIC COMPLEX

The Canton granite masses, like the Gouverneur, form a phacolithic complex consisting of two granite shells with an intervening zone of Grenville. It is shown on the Canton (Martin '16), Gouverneur (Cushing and Newland '25) and Ogdensburg (Cushing '16) geologic maps and in figure 38, based upon these maps. One

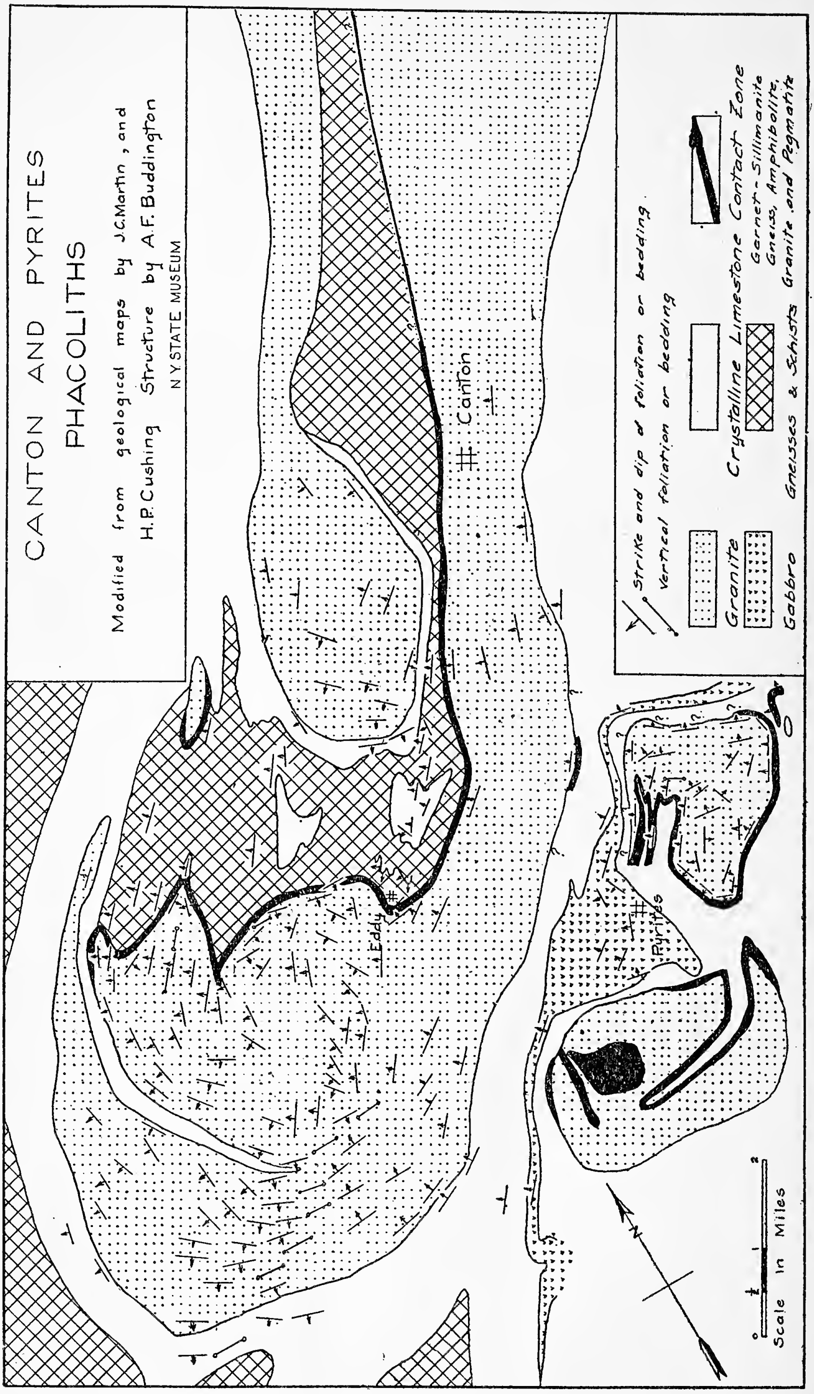



Figure 38 Canton and Pyrites phacoliths; Canton, Gouverneur, Ogdensburg and Russell quadrangles.

limb of the upper and outer phacolith passes through the town of Canton and forms a hook-shaped mass in the vicinity of DeKalb Junction. The inner phacolith lies a couple of miles west of Canton. The northern portion of the phacoliths can not be followed because of glacial debris and overlying Paleozoic sediments. The length of the complex as mapped is 15 miles, and the maximum width five miles. These masses have been previously described as sills by Martin. A detailed study of the structure, however, clearly suggests that they are phacoliths (figure 39).

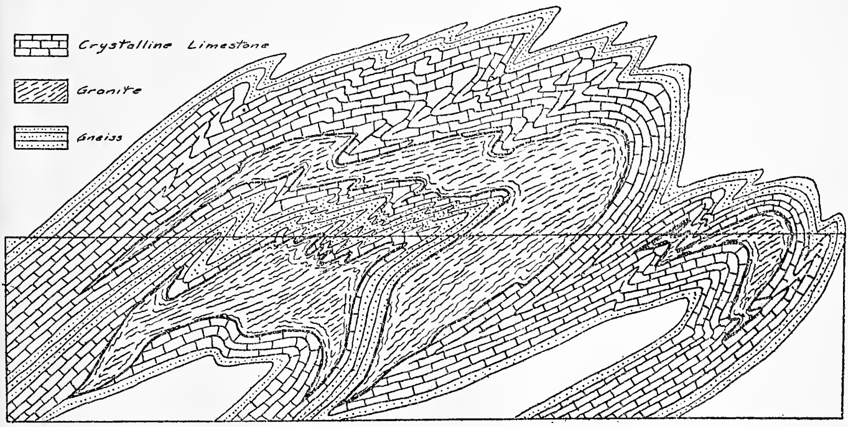



Figure 39 Hypothetical generalized structure section of Canton and Pyrites phacoliths.

North of Canton the country is largely covered with glacial and lake deposits, and the bedrock is obscured. The writer has not studied this portion of the area. The foliation of the lower phacolith, about two miles west of Canton, has an anticlinal character strongly overturned toward the southeast with a gentle southwest pitch. It constitutes an inner deeper phacolithic mass than that passing through Canton. The mass shows to a remarkable degree the results of the action of two stress components, the major one acting along northwest-southeast lines and producing a northeast elongation and the orientation of the major axis of the phacolith, and at the core a northeast foliation with a gentle uniform dip of 20°–25° NW; the other acting along northeast-southwest lines and producing a foliation with a northwest strike and gentle southwest dip at the south and southwest and locally along the west sides. Occasionally the results of the action of these two forces are present in the same outcrop, and the ledges may strike northeast and dip gently northwest, whereas their foliation strikes at right angles; or alternate ledges may have orientations at right angles to each other. About three miles from

the southern end, the anticline appears to be sharply pinched and continues thus to the northeast as far as mapped. A narrow valley filled with silts and sands surrounds the granite south of the Grass river. Martin maps a band of limestone along the west side and south end of the granite in the valley of Church brook. The writer believes that this limestone band very probably extends also along the east side and it is so shown in figure 38.

Between the inner and outer phacoliths lies a belt mapped as limestone and biotite, hornblendic, garnetiferous and calcareous gneisses, and whose structure is described in detail by Martin. Each limestone patch south of that around the inner granite mass appears to the writer to be brought up by a minor anticlinal dome, due to cross-folding by the minor northeast-southwest stress. The Grenville formations have an average pitch of about 10° southwest and pass beneath the outer phacolith which pitches down considerably steeper. The thickness of the Grenville beds can not be more than 750 feet, and is probably less. These Grenville strata constitute the base of the outer phacolith.

The outer phacolith has been so deeply eroded that most of its axial portion has been entirely removed, and only the sill portion of the southeast limb through Canton, the mass forming the plunging nose of the anticline at DeKalb Junction, and a mere remnant of the northwest limb remain. The result is a hook-shaped mass. Northwest of DeKalb Junction a curving band of limestone is included in the granite. The southwest nose of the anticlinal phacolith plunges about 30° SW, and the crenulate border of the mass on its inner edge is due to a series of minor anticlines and synclines striking northeast and pitching southwest. These are also well shown in the adjoining Grenville formations, and are beautifully, and in places most delicately, reflected in the foliation and structure of the granite. The southeast limb of this outer phacolith, southwest of Canton, has a minimum thickness of about 2600 feet. It thickens very greatly around the plunging anticlinal nose, where it varies from 10,000 to 13,000 feet, and then thins quickly to zero on the northwest limb.

The outer phacolith is entirely surrounded by a belt of limestone. At the southwest end, though much of the area is covered, the limestone can be traced around the nose by intermittent outcrops from a northeast strike and northwest dip, through an east-west strike and vertical dip, back to a northeast strike and northwest dip, thus conforming to the structure of an anticline overturned toward the southeast, with a dip of the axial plane about 30° NW, and pitching

to the southwest about 30°. The strike shown on Cushing's map about three-quarters of a mile northwest of East DeKalb is in error, for the strike is conformable to the border of the phacolith here and the dip is south. The foliation of the granite and the included amphibolite layers along the border conforms to this structure. There are, however, practically no layers of amphibolite south or west of the band of included limestone.

To the east and north of the included limestone band, there is a belt about a mile wide in which included layers of amphibolite are common. They conform in strike and dip to the limestone band and continue east of its termination, where they are parallel to, and conform in strike and dip to, the limestone along the southern and southeastern border of the mass. In other words, they form the skeleton of the nose of an overturned anticline within the body of granite. The foliation, on the other hand, is only in part conformable to the structure thus outlined, and in part is most discordant with it. The discordance is extraordinarily well shown for a mile radius north of DeKalb Junction in the sector between the Ogdensburg branch of the railroad and the main line. The foliation here is of two major types, one parallel to the included amphibolite layers and therefore with a variable strike and dip, and the other with a uniform north to northeast strike and moderate northwest dip. The latter is due directly to the major orogenic stress acting along northwest-southeast lines, and the former is due to drag of magmatic flowage against the included amphibolite layers and to an inherited foliation resulting from their disintegration and almost complete replacement. A local puckering, by the minor northeast-southwest orogenic force, of the foliation planes produced by the major northwest-southeast orogenic force has also contributed to produce a cross structure. The interplay of the major orogenic stress, and the inherited and drag foliation indirectly arising from the movements and activities of the magma are adequate to explain the phenomena shown here.

A number of thin sections of the granite were examined. The fabric varies from seriate homeoid to seriate intersertal. Except where the granite has been strongly affected by both stresses, it shows a texture characteristic of normal crystallization from a magma and with an aplitic or granulitic character. Locally where the foliation of the granite strikes northwest, there is a very prominent protoclastic or occasionally a cataclastic structure.

The contact zones of the outer phacolith are covered for most of their length. Martin has described and mapped a belt of amphibolite several miles in length adjacent to the northwest border of the granite northeast of Eddy, and suggests that it actually may extend

several miles farther to the northeast. The amphibolite is intruded and interbanded with the granite on the inner border. Martin ('16, p. 32–33) writes that a garnetiferous gneiss probably parallels and is adjacent to the amphibolite on the outer side of the contact zone; that the proximate rock of the amphibolite is never, so far as known, a normal or even an impure limestone; and the view is strongly suggested that the amphibolite and garnet gneiss are both the result of contact action on biotitic garnet-bearing schists.

The writer has studied this locality and finds that in the belt one to two miles northeast of Eddy the garnet gneiss referred to by Martin contains intercalated beds of limestone; that a feldspathic gneiss and a bed of thin banded feldspar-pyroxene-calcite granulite, with layers very rich in disseminated green pyroxene, intervenes between the garnet gneiss and the amphibolite; and that quartz-biotite schists and biotite-orthoclase gneisses are other members of the beds exposed here. A few thin rare veins of garnet-sillimanite gneiss were observed parallel to the foliation of these rocks, but in general this normal member of the contact zone is missing. The presence of the limestone and feldspar-pyroxene-calcite granulite beds here shows that nothing other than replacement of limestone is necessary to explain the amphibolite band. The garnet gneiss is a recrystallized sediment with accessory graphite; and it, together with the pyroxenic granulite, is the result of the action of pegmatitic and later solutions on the Grenville rocks, and does not represent an intermediate stage in the formation of the amphibolite. The garnet gneiss and quartz biotite schists appear to have been derived originally from siliceous and argillaceous beds interbedded with limestone.

The contact zone on the Ogdensburg quadrangle was not mapped by Cushing, but it can be traced around the crenulations resulting from alternating series of synclines and anticlines to the included limestone band by a series of intermittent outcrops. The contact zone consists here predominantly of black amphibolite, in considerable part garnetiferous and in small part of garnet-sillimanite granite sills, a few inches to several feet thick. The amphibolite often contains many thin pegmatite veins parallel to the foliation. The smaller ones usually have developed garnet within themselves, and often a thin border zone of garnet in the adjoining amphibolite. The larger pegmatite veinlets are usually free of garnet. The usual tourmaline-bearing pegmatite and quartz veins across the structure are also present. The contact zone is locally quite wide, due to isoclinal folding. The adjoining country rocks are covered.

Southwest of Eddy the normal pink granite, locally where in contact with inclusions of dark gneiss, contains sparse disseminated gar-

nets. This is a feature which is rare here and has not been observed elsewhere.

The garnet amphibolite is not a usual development of the contact zones and is probably due here to the presence of originally impure limestones, as is indicated by the association of schists with the adjoining limestone.

Martin also describes a contact zone at the southeast border of the Canton sill, 3.7 miles south of Canton. Here he describes amphibolite adjoining the granite, garnetiferous amphibolite farther from the contact, and then probably limestone. The two varieties of amphibolite have a thickness of about 25 feet, with additional inclusions in the adjoining granite. Martin interprets the two amphibolites to represent increasing degrees of metamorphism. The writer has not seen this locality, but the descriptions suggest that the garnetiferous amphibolite is the result of alteration of the normal amphibolite by late stage magmatic solutions.

## PYRITES PHACOLITH

The Pyrites granite mass is located just northeast of Pyrites in the southwest corner of the Canton quadrangle. The granite and its border zone have been mapped and described by Martin ('16, p. 26–34; 52–53; 65–78; 108), who, however, refers to it as a boss "for lack of a better name." He writes of it as having been intruded between two contiguous horizons in the Grenville. The Pyrites mass is shown in figure 38 and is copied from Martin's map, with strikes and dips inserted as determined by the author, and a minor change in the mapping of the thin limestone band on the northwest side of the reentrant. The writer would interpret this as a phacolith with subsidiary crumples, caught in overturned folding. It will be seen that the large southern thumb of the granite mass has a well-defined domical foliation overturned towards the southeast, and that the foliation is everywhere parallel to the borders. The deep reentrant on the southwest the writer would interpret as an isoclinal syncline dipping gently northwest and with the axis pitching steeply southwest, as does the adjoining portion of the anticlinal dome to the southeast. There is a most extraordinary discordance between the strike and dip of included amphibolite layers and the strike and dip of the foliation in a belt extending about a half mile northeast of the reentrant. In the granite the pitch strikes west-northwest and is as prominent a structural feature as the strike of foliation. These features of the granite have been described in detail by Martin and referred to forces acting respectively from the northwest and the northeast, an interpretation with which the writer is in agreement. The writer would interpret

the general northwest trend of the amphibolite layers at this locality as forming part of the synclinal structure indicated by the reentrant, for which this strike would be normal and appropriate.

At the northeast end of the mass the strike and dip change from a northeast strike and steep northwest dip to a west-northwest strike and a moderate north dip, through an intermediate stage where the dip is vertical. Martin has described in detail the manner in which the included amphibolite layers are crumpled back on themselves where they round the turn and strike northwest. A photograph by Martin of such transverse crenulations is reproduced in figure 46.

Rock of the type and relations of the contact aureoles around granite masses of this kind were first systematically described by Martin ('16 p. 26–30), although his explanation of their origin differs from that to be offered by the writer. Martin writes:

The garnet gneisses, whose peripheral association with areas of granite gneiss has given cause for the suspicion that they are contact aureoles, are found in the general vicinity of Pyrites. The prominent granite upland east of this village is bordered by a zone of garnetiferous rock, 20 or 50 feet broad, which is continuous half way round the boss to the head of the reentrant. At the northeast end of the reentrant, the garnet gneiss describes a group of remarkable curves.

The idea that the garnet gneisses are of the nature of contact zones, produced by the action of intrusive granite upon Grenville limestone, is attractive. While certain points of the field evidence favor this, it must be concluded, however, that on the whole the proof can not at present be definitely established . . . the other side of the question appears to be more convincing ... the failure of the rock to form an uninterrupted zone around the granite, its resemblance to other garnet gneisses of admittedly sedimentary origin, and the inclosure of a thick strip of apparently sedimentary garnet near the west border of the granite, are facts which are in favor of regarding the rock in question as fragments of a sedimentary series, which owe their present position adjacent to and within the granite, to purely accidental circumstances of a tectonic nature.

Further, it is not noticeably different from the tapering mass of garnet gneiss bordering the northwest side of the reentrant. In this case the garnet rock is interbanded with normal crystalline limestone. If the peripheral gneiss is a contact rock, so is this. Nevertheless, in the latter case, it is difficult to admit a degree of selective silicification sufficient to produce two parallel belts of garnet gneiss and leave unchanged between them a layer of normal crystalline limestone identical with that from which the contact hypothesis would suppose the aureole to have been produced.

There is no transition from the garnet gneiss to the granite on the one hand, nor to the limestone on the other. On the side facing the intrusive, the garnet rock is often cut parallel to the banding by sill-like dikes of granite. Quartz, orthoclase, biotite and garnet are the

essential constituents, accompanied by accessory pyrite and magnetite, and scapolite flakes developed at the expense of feldspar and garnet.

The writer finds that the peripheral contact rock of the granite here is the typical garnet-sillimanite gneiss, composed of garnet, microperthite, plagioclase, quartz and sillimanite, with microperthite usually the predominant feldspar, but with plagioclase locally equal in quantity to the microperthite. Biotite, ilmenite, apatite and tourmaline are accessory minerals. Locally, the sillimanite is partially or wholly altered to sericite and the plagioclase to scapolite. The sill northeast of the main body is also a typical sillimanitic garnet gneiss. Along the north and northwest boundaries of the granite body the contact is covered, and the border rim of garnet-sillimanite gneiss may well be present here also, at least, locally. The belt of gneiss bordering the northwest side of the reentrant the writer would interpret as of mixed origin, comprising sills of garnet-sillimanite gneiss, layers of garnet gneiss resulting from the injection of biotitic gneiss by pegmatitic solutions, and interlayered beds of limestone and gneiss, in part garnetiferous, resulting from the recrystallization and alteration of sedimentary rocks. The garnet-sillimanite gneiss sills contain included layers of amphibolite and gray biotitic gneiss, and locally thin layers of limestone. Occasionally the garnet-sillimanite gneiss may be observed to break across these included layers in the same manner as does the normal granite. Sill-like sheets of granite occur between bands of the garnet-sillimanite gneiss, but the writer has nowhere noticed any case of the granite definitely cutting the garnet-sillimanite gneiss. Thin veinlets of quartz occur parallel to the foliation. The amphibolite predominantly and normally consists of hornblende and plagioclase. Locally relics of pyroxene in process of alteration to hornblende are found, or the amphibolite may be garnetiferous. The garnet in some specimens is apparently the latest mineral to develop. Accessory magnetite and apatite are always present.

The peripheral contact rock usually shows pronounced cataclastic effects, although specimens from the core show only moderate protoclastic structure.

A most extraordinary symmetrically well banded high temperature fissure vein, which cuts the contact aureole of the Pyrites granite mass and also cuts the pegmatite veins which cut the aureole, has been described by Agar ('23, p. 129–130). In it, diopside was deposited first, followed successively by diopside and phlogopite, diopside and apatite, phlogopite, and at the center of the vein calcite with a little apatite, wernerite and titanite.

## GRANITE PHACOLITHS IN GNEISS AND QUARTZITE

The Edwards, Butterfield Lake, and Clark Pond granite masses are intrusive into Grenville gneiss and quartzite. The first two consist of a large number of separate intrusions of granite in a meshwork of gneiss and quartzite with interbeds of limestone, the aggregate forming an oval-shaped area constituting a unit. The structural relations of these masses are so confused, and there is so much intermingling of gneiss and granite, that accurate mapping is impracticable. The Clark Pond granite mass has a definite anticlinal relation to the inclosing Grenville gneiss, although there is a network of dikes interpenetrating the gneiss along the borders, and the granite contains many inclusions. The Grenville gneiss in turn bears an anticlinal relation to the overlying limestone. The writer believes these granite masses have had a similar mode of intrusion to those in the limestone, complicated by the greater tendency for brecciation exhibited by the gneisses and consequently more evidence of transgressive contacts.

Along both the American and Canadian sides of the St Lawrence river, in the vicinity of the Thousand Islands, there is a large mass of fine to medium-grained granite with many inclusions of the Grenville formations. This mass on the American side has been called the Alexandria batholith of Laurentian granite by Cushing (Cushing and others '10, p. 36), and on the Canadian side it is referred to as the Mallorytown granite by Wright ('23), and is apparently included in the Algoman batholith by Baker ('23, p. 10–11). Baker also designates as the Algoman batholith a coarse-grained to porphyritic granite called the Brockville by Wright; a similar granite is called the Picton by Cushing. The granite mass is exposed for a length of 25 miles and a width of about 15 miles. The included bands of Grenville, northwest of the St Lawrence, are stated by Wright to strike northeast and dip steeply northwest. Within a belt of mixed Grenville quartzite, gneiss, limestone and granite, about four miles wide, along the southeast border of the granite mass the strike is northeast and the dip steep southeast. On Wellesley island, in the south half, many of the dips are southeast.

To the southeast, on the Hammond quadrangle, overlying the quartzite and gneiss belt is a broad belt of close-folded limestone; and similarly overlying the granite, with included quartzite and gneiss, on the northwest in Canada is a broad belt of limestone. As Wright ('23, p. 46) suggests, there is here a major anticlinal structure, probably caused by the intrusion of large quantities of granite magma under considerable lateral pressure. There are doubtlessly many subsidiary tight squeezed folds with steep axial planes, and the rigid

quartzites and gneisses have been much broken up by the intrusion of the granite, but the writer suggests that possibly this mass is an intrusion of complex phacolithic type.

## PORPHYRITIC GRANITE MASSES (HERMON TYPE)

A number of the smaller porphyritic granite (Hermon type) bodies appear to be clearly normal sills in the Grenville rocks. The larger masses, however, roughly conform to the major synclines and anticlines of the Grenville formations. The larger bodies are shown in figure 33.

The Hermon mass shows a hook shape at its southwestern end. The Grenville formations here consist of a crystalline limestone member overlain by garnetiferous injection gneiss, and both are thrown into a closely compressed overturned syncline which forms the short prong and is bordered by an overturned anticline on the southeast. Both folds pitch southwest. The granite is continuous around both the anticline and syncline. In the lower limb of the anticline it lies near the base of the garnet gneiss, but around the syncline it cuts gradually across about 3000 feet stratigraphically of garnet gneiss, comes against the limestone about at the nose of the syncline, and then continues gradually to cut across the limestone for about 3000 feet southwest along the northwest limb of the syncline. It thus transgresses gradually across about 6000 feet of sediment. Cushing (Cushing and Newland '25, p. 68–69) describes an overturned narrow syncline of garnet gneiss and limestone within the granite band on the Gouverneur quadrangle.

Another mass of porphyritic granite directly related to, and conformable with, the structure is shown at the north end of the California anticlinal phacolith, and a mass at the same horizon occurs on the nose and limb of an adjoining syncline which pitches northeast.

Around the Edwards phacolith there are several masses of porphyritic granite which, taken together, outline a granitic belt conformable with the formations around the Edwards anticlinal phacolith. Another hook-shaped mass lies northwest of the prong of the Hermon body, and is conformable with a syncline in the enclosing limestone. Numerous other smaller masses conformable to minor folds have been mapped, but are not shown in figure 33.

The porphyritic to coarse equigranular granite of the Hermon type very rarely shows cataclastic efforts. The texture is either that of normal interlocking or polygonal type characteristic of direct crystallization from a magma, or a protoclastic type due to crushing of a partly liquid, partly solid, mixture.

## MECHANICS OF INTRUSION

The granite masses of the Alexandria type in the Grenville formation of the northwest Adirondacks are all interpreted by the writer as phacoliths. The term phacolith was first proposed by Harker ('09, p. 76–78) for concordant intrusions in which preexisting structures in the country rocks have exerted a directing influence in conjunction with the mountain-building forces. In cross section he states that it presents typically a meniscus or sometimes a doubly convex form, usually has a long diameter in the direction of the axis of folding, and the ideal phacolith is subject to many modifications, in accordance with varying mechanical conditions of intrusion.

The interpretation of the masses under discussion as phacoliths is based upon the restriction of the granite bodies to anticlinal folds; to the general conformity between the borders of the granite mass and the bedding of the country rock, both on the limbs and the noses of the folds; upon the actual exposure of a base to a major phacolithic shell in the Canton complex; and upon the contemporaneity of the folding and intrusion, as indicated by phenomena connected with the foliation and texture of crystallization. The phacoliths are not restricted to any particular horizon, but occur throughout the Grenville series. Minor folds, including both synclines and anticlines, are a common feature on the axial portions and noses of the major phacolithic structures. They are well exemplified in many of the masses under discussion, and give rise to their crenulate ends. The Payne Lake, Hyde, and California phacoliths are accompanied by subsidiary intrusive sills in a relation similar to those often accompanying laccolithic intrusions.

The folding, form of intrusion and foliation of the phacoliths of the northwest Adirondacks are the result of the interplay of pressure exerted by the magmatic intrusions and of control by an orogenic pressure acting along northwest-southeast lines. The results are also as though a minor tectonic force or component acted contemporaneously along north-northeast — south-southwest lines. The magma itself acted as an agent in making these forces effective.

The major force, except in a long belt parallel to Black lake, produced the pronounced overturning towards the southeast of all the folds, the elongation of the phacoliths along northeast-southwest lines, and the predominant foliation with a northeast strike and moderate northwest dip. In the Black Lake belt, with a width of about four miles and an exposed length of 22 miles, it produced overturned folds towards the northwest and a predominant foliation in the Butterfield Lake and Fish Creek phacoliths dipping 60°–70° SE. In the

case of belts of injection gneiss, which, on the ends of pitching folds, strike more or less parallel to the northwest-southeast stresses, there is a marked cross crumpling and plication of the rock, particularly well shown in some of the pegmatite veins. An example of this has been previously described (Smyth and Buddington '26, p. 74–75).

The cross structures, as though produced by forces acting along north-south to northeast-southwest lines, include the marked pitch to the axes of the major folds, a multitude of minor folds and flutings locally on the limbs of the major folds, and the broad belts of granite with foliation striking west-northwest as at the north end of the Gouverneur and Pyrites phacoliths, west at the north end of the California mass, and west to northwest in the southern portion of the two shells of the Canton phacolithic complex. The west-northwest pitch, due to cross folding, which is very prominent in the southern half of the Canton quadrangle has been interpreted by Martin as indicating stress acting at right angles. From figure 33 it will also be seen that there is a rough tendency for the phacoliths to lie within northwest-southeast belts. The pitch of the major folds is usually about 30° to 40°, though locally on the Hammond quadrangle pitch as steep as 50°–60° is found, and in the Pierrepont sigmoid Martin gives the pitch as 70°–75°.

The hypothesis that the foliation originated previous to the complete consolidation of the magma is an essential element in the interpretation of these bodies as phacoliths. In the granite of several of the phacoliths there is scarcely a trace of cataclastic structure. In the Hyde, Hickory Lake, California, Gouverneur, and Reservoir Hill bodies, the texture is almost wholly that arising from direct crystallization from the magma, and there is practically no protoclastic structure, except at the periphery of the phacoliths, and only a little even here. It is true that much or all of the Fish Creek, Butterfield Lake, Dodds Creek and Pyrites phacoliths show marked cataclastic structure, but they lie within local belts in which all the rocks have been subjected to severe crushing. The mashing is most marked in the periphery of these granite bodies, and protoclastic structure without cataclastic effects is found in the rock of the cores of some of them. At several localities layers of amphibolite which lie athwart the foliation of the enclosing granite have had a foliation corresponding to that of the granite induced in them, and granitic solutions have penetrated along these planes. Where the foliation of the granite has been produced by drag against the country rock or included layers of amphibolite, there are usually pegmatite veins parallel to the foliation. These phenomena all indicate that the foliation must have been formed before the complete consolidation of the granite.

Other very strong evidence in favor of the idea of development of the foliation previous to the complete consolidation of the magma is found in the local discordance between the foliation of the included amphibolite layers and that of the granite. This is shown locally in all the granite masses, but is exceptionally well shown north and west of DeKalb Junction in the Canton phacolith previously described, and in the northwestern half of the Fish Creek phacolith. In the latter,

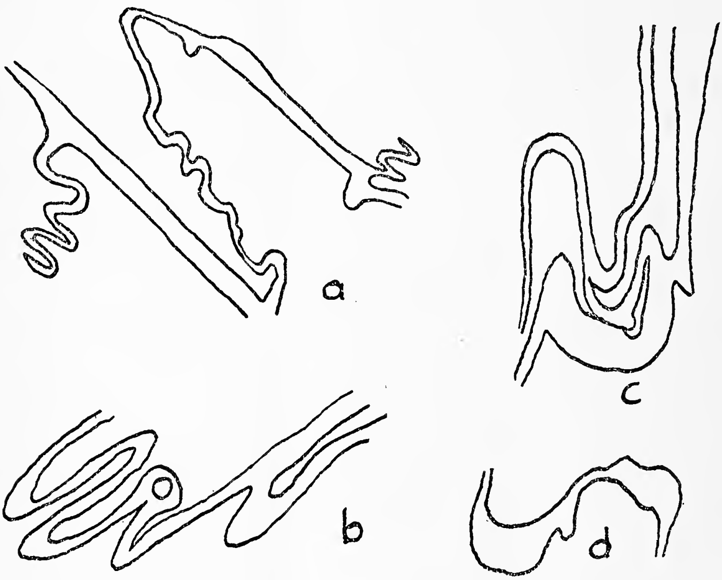



Figure 40 Folded pegmatite veins and granite sill.
(a) Granite pegmatite vein in limestone crumpled by minor force along NE-SW lines. Ground plan. Near Laidlaw School, Hammond quadrangle.
(b) Granite pegmatite vein in limestone crumpled by major force along NW-SE lines. One mile west of Stark School, Hammond quadrangle. Ground plan.
(c) Crumpled granite sill in limestone. Vertical face looking east. Just south of large folded granite sill (Hermon type) near Pleasant Lake, Hammond quadrangle.
(d) Crumpled pegmatite vein, ground plan, showing thickening on axes and thinning on limbs.

the amphibolite layers strike northwest with their own foliation parallel to the borders, whereas the foliation of the granite strikes northeast. Locally the amphibolite layers are crumpled back on themselves, in which case there is a tendency for the development of a foliation consistent with that of the granite. Locally, also the amphibolite layers are broken up, and the foliation of the disrupted fragments may be at an angle to that of the granite.

At very many localities, pegmatite veins in the Grenville rocks are folded, crumpled, and plicated along with the sedimentary beds, both on a large and small scale (figure 40). A systematic study has not been made of the microstructure of such pegmatite veins, but enough has been done to show that, for the most part, they were crumpled before complete consolidation and show a protoclastic structure. In part, however, the pegmatite veins have been broken into angular fragments and pulled apart by flowage of the inclosing limestone, subsequent to their complete consolidation.

In the peripheral zone of the phacoliths the orientation of the foliation was controlled by the pressure exerted by the inclosing limestone which was undergoing folding, by the drag flowage of the magma against the limestone country rock and the included layers of amphibolite, and to an inherited foliation resulting from the disintegration and all but complete replacement of included amphibolite layers. In the cores of the phacoliths the foliation was almost exclusively controlled by the dominant tectonic stresses acting along northwest-southeast lines. Locally the results of drag and inherited foliation parallel to included amphibolite layers, on the one hand, and the dominant orogenic foliation on the other, may be seen in the same outcrop or within the same area.

There is much evidence that the magma itself has exerted such pressure as to have been an effective agent in conditioning the location and phenomena of the resulting form. At the northeast end of the California phacolith, a thick belt of garnet gneiss has been broken along a fault and displaced for over a mile, apparently in direct genetic connection with the intrusion of the granite magma. The constant association of the granite masses with anticlines in the Grenville rocks must be due in part to the magmatic pressure.

There is very probably, locally, considerable transgression and crosscutting of the country rocks by the granite masses, but this is difficult to prove in the limestone belts, due to the prevalence of covered areas along the contact. The writer believes that the magma made room for itself largely by entering potential low pressure zones on the crests of anticlines and there displacing the rocks which, in the case of the limestones, yielded largely by flowage, and in the case of the gneisses and quartzites, in part by flowage and in part by brecciation and displacement within the uprising magma. The magma itself was doubtless an active agent tending to form the anticlines.

If we were dealing with phenomena at the immediate surface of a batholithic intrusion, there might normally be expected many more

sills than are found and a number of small stocks and bosses. A body of batholithic type may well lie at some depth below the present surface of this region, but the granite masses under discussion are here interpreted as having a connection with it by way of feeding dikes, sills or pipes, rather than as actual superficial parts of it.

A study of the structural relations of the porphyritic to medium-grained granites of the Hermon type has not afforded the writer as positive and definite evidence of their mode of intrusion as did the fine to medium-grained granite of the Alexandria type. A major problem here is raised by the statement of Cushing (Cushing and Newland '25 p. 38–40), that the Alexandria granite is of Laurentian age and older than the porphyritic granites and the syenitic intrusives, and that the porphyritic granite was intruded into a series of already isoclinally folded beds (p. 65 and 69). This would mean, necessarily, that the conformity of the porphyritic granite sheets with anticlinal and synclinal structures, such as have been previously described in this paper, is merely the result of magma following up along the bedding planes in conformity with their overturned closely folded structure. Ordinarily such close conformity in structural relations as is represented here would be ascribed to contemporaneous folding of both granite and inclosing country rock. But this could only be if the granite were older than or contemporaneous with the folding.

The writer has studied the relations of the igneous intrusive masses throughout the northwest Adirondack belt, including a number of the localities in the Thousand Island region referred to by Cushing. He is unable to confirm Cushing's conclusions as to the relative ages of the intrusives, but finds that the meta-gabbro, diorite, monzonite and syenite intrustives are definitely older than both the granite (Alexandria and Hermon) and have been subjected to intense folding, and has failed to find any decisive field evidence as to whether the alaskitic granite of the Alexandria type is older or younger than the porphyritic to medium-grained granite of the Hermon type.

If this interpretation is admitted, it permits of the assumption that the general conformity between the structure of the Hermon type of granite and the Grenville formations, as well as that of the Alexandria type, is also due to contemporaneity of intrusion and folding.

A study of the geologic maps shows that the anticlines on which the phacoliths of the Alexandria type of granite occur do not necessarily constitute the major folds, but are in most cases subsidiary folds within a greater major structure. The Hermon granite sheet conforms with such a major structure and has an exposed length of more than 40 miles.

The structural relations of the granite masses of the Hermon type to the Grenville formations and of the meta-gabbro to the Grenville beds are similar. The meta-gabbro is the oldest intrusive and is definitely folded along with the Grenville, as has been most conclusively proved by Martin ('16), and confirmed by the writer. The hypothesis is therefore suggested that the Hermon type of granite was intruded into the Grenville formations at an intermediate stage of the folding, mostly as sheets parallel to the bedding, but locally breaking across thousands of feet of the beds at a low angle, and was subsequently folded with the inclosing rocks. The lack of cataclastic structure and brecciation in the granite and the local presence of protoclastic structure indicates that this folding took place before its complete consolidation. The occurrence of the granite continuously in both synclines and anticlines suggests that it was intruded widely at a period when the folds were open and gentle.

The writer has no decisive evidence that the Hermon type of granite could not have come into a series of previously isoclinally folded beds, as postulated by Cushing, but he believes that the balance of evidence at hand favors the idea of early intrusion and contemporaneous and subsequent folding.

The garnet gneiss belt around the northeast end of the California phacolith has been offset over a mile by faulting, attendant upon ntrusion of the granite magma which formed the phacolith. If the two ends of the garnet gneiss belt are joined, the two separated parts of the porphyritic granite sheet around the California phacolith will also be brought into juxtaposition, thus suggesting that they likewise were intruded earlier than the granite magma of the California phacolith and separated at the time of its intrusion.

The folding of the granite sheets (Hermon type) is further discussed in connection with the Rossie sill complex on a later page.

## PARALLELISM OF FOLIATION AND BEDDING

The foliation of the Grenville formations is everywhere parallel to the bedding in the northwest Adirondacks. In many regions of close-folded bedded rocks which have been subjected to strong lateral pressure, such as the Appalachians, a foliation has been induced which tends to be parallel to the axial planes of the folds and to cross the bedding, especially along the crests and troughs of the folds, although it may be parallel to or at a slight angle to the bedding on the limbs. The uniform parallelism of the bedding and foliation in the Adirondacks was recognized by Van Hise ('96, p. 773), who

suggested that it might be due to mere downward weight of overlying rock unaccompanied by side pressure. This hypothesis has been adopted by Miller ('16) and Cushing (Cushing and Newland '25, p. 51–55). Miller uses this hypothesis as favoring the idea that the Grenville of the Adirondacks, with the possible exception of the northwest Adirondacks, has never been subjected to orogenic stresses or strongly folded.

The writer believes that so far as the northwest Adirondacks is concerned, there is no justification for assuming that if the foliation and bedding is parallel it must have been formed by "load or static" metamorphism. In the northwest Adirondacks the folding and granite intrusions have been shown to be contemporaneous. The writer would ascribe the foliation to recrystallization accompanying the deformation and igneous intrusions. Where strong folding is present without magmatic intrusion, nonuniform pressure is a dominant factor and cleavage across the bedding may be produced; but it is unwarranted to assume that a similar relation would hold where there is abundant magma injected contemporaneously with the folding and the beds are permeated with magmatic vapors and solutions. Stress relations must be very different in a system composed of part liquid and part solid from what they would be in one wholly solid. The foliation of the granite masses at their roofs and in the troughs is parallel to the border, indicating that the major pressures here were directed upwards or downwards, and not laterally. Recrystallization must be a dominant factor during such regional igneous invasion, and the bedding planes may well condition the orientation of the minerals, as it has the form of the intrusions and the border foliation of the intrusive masses.

## GABBRO, DIORITE, QUARTZ DIORITE, AND MONZONITE INTRUSIVES OF THE GRENVILLE BELT

The writer believes that gabbro forms the oldest intrusion of which we have definite knowledge in the Grenville formations of the northwest Adirondacks. It occurs almost exclusively as sills, for the most part parallel to the bedding, but locally crosscutting. Small lenses parallel to the bedding are common locally in the limestone, and rarely a small stock is found. The gabbro has been tightly folded along with the Grenville formations. This has been proved conclusively by Martin ('16, p. 96–108), who has described in detail the great Pierrepont sigmoidal fold, where the limbs have been overturned so that they dip 30° NW, and the axes have been tilted so that the pitch is about 70°–75° NE. Other examples of folded

gabbro sills are found around the northeast end of the California granite phacolith on the Lake Bonaparte and Gouverneur quadrangles, and near Pleasant lake on the Hammond quadrangle.

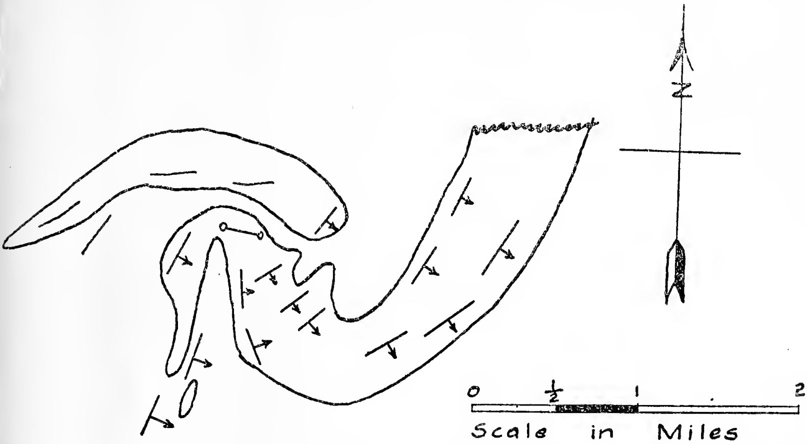



Figure 41 Sketch of monzonite sill isoclinally folded with steep SE dip; north of Pope Mills, Hammond quadrangle.

Monzonite occurs throughout the Grenville belt of the northwest Adirondacks as sills from two to eight miles long. They are very probably outlying masses, genetically connected with the great granite-monzonite mass represented in the main Adirondack area.

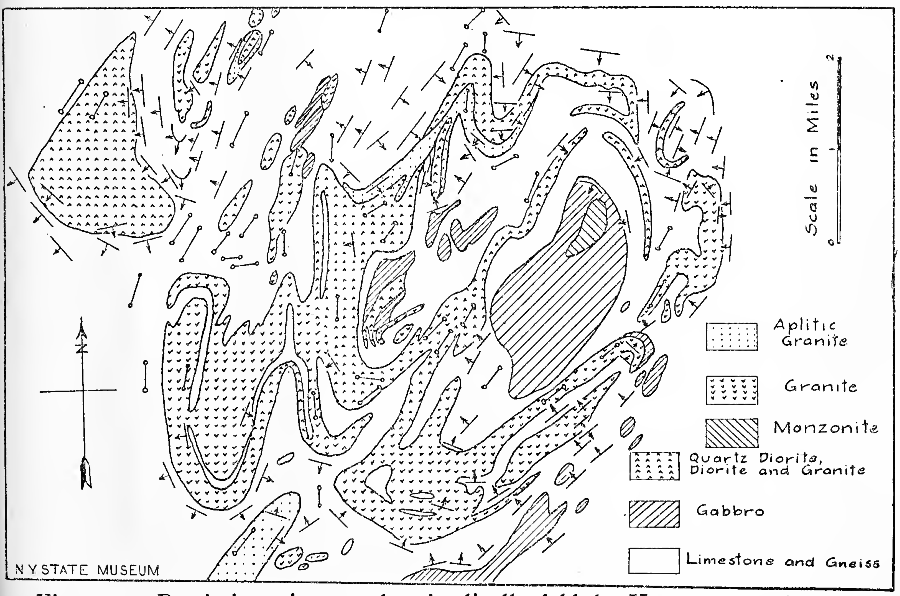



Figure 42 Rossie intrusive complex, isoclinally folded. Hammond quadrangle.

It is younger than the gabbro, diorite and quartz diorite, and older than the granite (Alexandria type). North of Pope Mills, on the Hammond and Ogdensburg quadrangles, a sill of monzonite (figure 41) has been folded back on itself by forces acting along a northwest-southeast line, so that the axial planes of the fold dip steep southeast. The microscopic structure of this mass is cataclastic throughout.

On the Hammond quadrangle near Rossie there is an intrusive sill or sheet complex (figure 42) which has been isoclinally folded

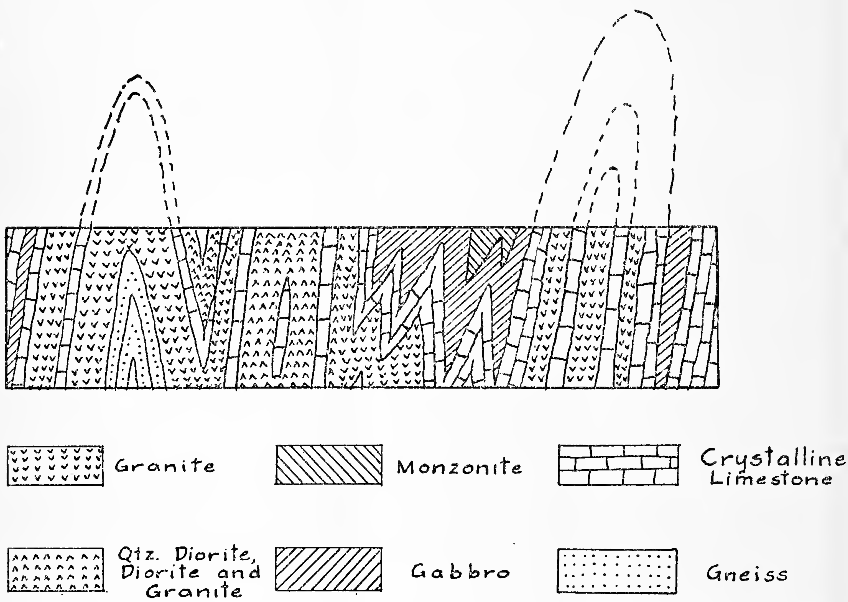



Figure 43 Generalized structure section of Rossie isoclinally folded intrusive complex.

(figure 43). The igneous rocks form about one-half of the total mass and include all the common kinds of intrusive rock of the Grenville belt of the northwest Adirondacks. The country rock is crystalline limestone, full of pegmatite veinings and nodules and disseminated silicates, and with intercalated bands of gneiss or granulite all showing minor crumplings. The oldest member of the igneous complex is gabbro. This forms sills at two or more horizons in the Grenville, and numerous small lenses. The next younger member comprises dioritic intrusives. These vary from pyroxene and hornblende diorite to biotite quartz diorite. The quartzose facies are predominant. Much of the quartz dioritic rock is interbanded with younger granite. The dioritic rocks, like the

gabbro occur as intrusive sills and small lenses, for the most part at different horizons from the gabbro but locally intrusive into the latter. The larger mass in the northwest corner of figure 42 is a small laccolithic intrusion of biotite-pyroxene quartz diorite, now turned up on edge by folding. Its base on the east side is about two miles long, with a maximum height of one mile to the southwest. The monzonite forms only a small mass. It is younger than the dioritic rocks and the gabbro, and is older than the granites. It forms a sill in the roof portion of the large mass of gabbro exposed in the Lake Pleasant syncline. The granite (Hermon type) contains numerous included layers of the Grenville beds, which facilitate the unravelling of the structure. It occurs as conformable interbands with the dioritic rocks, but for the most part as sills in the Grenville. A few small lenses are also found. In the northwestern half of the complex, the granite is for the most part medium-grained and in the field impossible to distinguish from the quartz diorite with which it is locally associated. South of the complex there is a phacolith of granite, Alexandria type. The anticlinal nose plunging northeast is shown at the lower edge of figure 42. A sill of aplite, folded along with the associated quartz diorite and gabbro, forms part of the northern composite sill. The granite is intrusive into the dioritic rocks parallel to their foliation. The granite, diorite, and quartz dioritic rocks for the most part occur as sills but transgressive dikes connecting sills at different horizons are also present. The folds of this complex strike north to north-northeast and are tight, with a dip of about 80° west to vertical. All of the major folds northwest of the gabbro syncline have a pitch of 45° to 50° S to SSW.

The micro-structure of the gabbro, diorite, and quartz diorite masses varies from highly mashed cataclastic to massive with no evidence of crushing except a ribboned wavy extinction in the quartz. Mashing is often particularly prominent along the border zones. The foliation is of primary magmatic origin, and not related to the degree of crushing. In some of the rock the foliation is very indistinct. These rocks may have been folded after complete consolidation. The gabbro mass of the Lake Pleasant syncline is intensively broken up and brecciated by granite pegmatite veins, but the micro-structure of much of it shows no cataclastic phenomena. Much of the diorite and quartz diorite shows cataclastic structure, and mosaic faulting on a small scale was noted at several localities. No protoclastic structure was seen in any of these rocks. The micro-structure of the granite (Hermon type) is for the most part massive, but there are local zones where crushing has been intense. There is no protoclastic

structure. Most of the granite is about equigranular and medium-grained, indicating a more quickly chilled facies than the coarse porphyritic stuff of the larger sheets to the southeast. The foliation must be of primary magmatic origin, as there is no crushing or alteration in most of the granite. The amount of crushing and faulting in the granite is so small that it seems as if the folding of the granite sheets must have occurred for the most part before complete consolidation, although in part they were probably intruded into rocks already somewhat moderately folded. The aplite sill has a typical aplite micro-structure and shows no trace of crushing. It must have been folded while yet partly liquid.

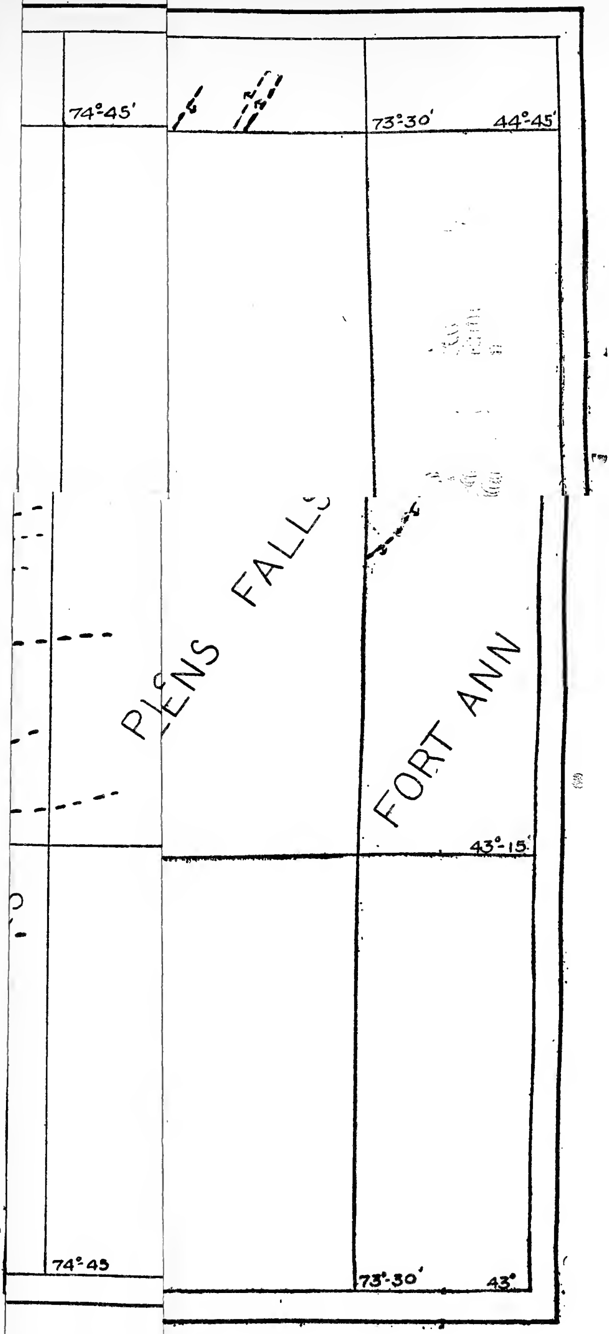
All the sills show local crosscutting relations to the Grenville formations but in general they are comformable.

## PRECAMBRIAN INTRUSIVES OF THE ADIRONDACKS AND THE REGION NORTH OF THE ST LAWRENCE RIVER

The problem of the igneous intrusives of the northwest Adirondacks is but a part of the general problem of the intrusives of the whole Adirondack area and of the Precambrian area north of the St Lawrence in Canada.

A brief summary survey of the characters of the great composite body of intrusives forming the Adirondacks will be given here.

In the east central part of the Adirondacks is a mass of labradorite anorthosite (Marcy anorthosite) which grades into a gabbroic facies (Whiteface anorthosite) on the outer borders and also locally in contact with included masses of Grenville beds. The anorthosite is relatively free from inclusions in the central portion, but does contain scattered metamorphosed sedimentary blocks here and there throughout much of its mass. Intrusive into the anorthosite and forming a great belt completely surrounding it is a body of igneous rock of variable character with many sheets, inclusions and belts of the Grenville formations. In general, these intrusions vary from augite hypersthene-monzodiorite, through augite and hornblende monzonites and quartz monzonites, to granite; but the monzodiorites and monzonites appear to be largely restricted to the northern and northwestern Adirondacks, so far as shown on the geologic maps available. The igneous rocks of the southern and southwestern Adirondacks are predominantly augite quartz monzonite, and hornblende granite. The rocks referred to as monzonite and quartz monzonite here have a syenitic aspect and are usually referred to as syenites, and granosyenite or quartz syenite. Alling (Kemp and Alling '25, p. 44–58)




ized trends of


Figure 44 Generalized trends of foliation in the Adirondacks

prefers to describe them as laurvikite, nordmarkite, quartz nordmarkite, and soda granite.

Of the many major facies found in the main body of the Adirondacks, only the hornblende monzonite, granite porphyry and alaskitic variety of granite find their counterparts as major intrusives within the Grenville belt of the northwest Adirondacks. The meta-gabbro which is common throughout the Grenville belt is not common in the main intrusive body to the southeast. There are, however, here and there throughout the intrusives, included bands, belts and masses of hornblende gneiss which is believed in part to have been derived by the breaking up of gabbro sheets.

A study by the writer of all the available published data on the foliation of the monzonite or syenite-granite series and of the included Grenville formations of the whole Adirondacks has shown that a characteristic feature is the alternating direction of dip in successive belts, the change taking place both through the vertical and the horizontal (figure 44). The changes in the mineral character of the intrusive, however, are independent of the changes in dip. There are locally a number of places where the strike completely boxes the compass, as though around a syncline or anticline. At many localities in the Lake Bonaparte and Lowville quadrangles the writer has observed a pronounced pitch in the orientation of the minerals of the igneous rock.

Miller ('16) has presented convincing evidence that the foliation is primary and induced before the complete consolidation of the magma. This has been confirmed by Smyth and Buddington ('26, p. 48–78) for the northwest Adirondacks.

The problem of the mode of intrusion of the Precambrian igneous rocks of the Adirondacks and Canada has been considered by a number of geologists, whose ideas are summarily presented here.

Miller ('18 p. 453–59) has interpreted the gabbro-anorthosite body of the east central Adirondacks as a laccolithic mass, and the great volume of syenite-granite, with associated included beds of Grenville, as a crosscutting batholithic body. Miller ('26, p. 65) further believes that "the Grenville strata of the Adirondacks have never been highly folded or severely compressed, and that the structural relations of the Adirondack Grenville strata are reasonably explained as having been the result of the slow irregular upwelling of the great bodies of more or less plastic magmas, probably under very moderate compression, whereby the strata, previously deformed little or none at all, were either broken up, tilted, lifted or domed, or engulfed by the magma."

Bowen ('17, p. 222–27) has suggested, in a very tentative way, that both the gabbro-anorthosite and the syenite-granite bodies belong to a huge laccolithic or sheetlike mass, which has been subjected during consolidation to considerable disturbance.

Alling ('18) believes that the syenite-granite magmas, called by him of Algoman age, were intruded subsequent to the folding of the Grenville formations, and in many diagrams shows the igneous rocks almost uniformly crosscutting the sediments, though in one figure he shows a small gabbro laccolith.

In the Haliburton-Bancroft area in Ontario, Adams and Barlow describes bodies of Precambrian gneissoid igneous intrusives similar to those of the Adirondacks as

> batholiths, great lenticular-shaped, or rounded, bosses, which are found arching up the overlying strata through which they penetrate, disintegrating the latter, and which possess a more or less distinct foliation, which is seen to conform in general to the strike of the invaded rocks when these latter have not been removed by erosion. . . . Within the batholiths themselves the strike of the foliation follows sweeping curves, which are usually closed and centered about a certain spot within the area of the batholith, where the foliation becomes so nearly horizontal that its course, or even its existence on a flat surface is difficult to recognize. From these central areas of flat-lying gneiss, the dip of the gneisses where it can be determined is generally outward in all directions. The batholiths, therefore, are undoubtedly formed by an uprising of the granite magma, and these foci indicate the axis of greatest upward movement, and those along which the granite magma has been supplied most rapidly. . . . In the case of Methuen batholith, the surrounding rocks where they can be determined, are found in almost all cases to dip inward toward the invading granite gneiss. . . . These masses have evidently eaten their way up into downward sagging portions of the overlying sedimentary series. . . . The movements in the granite, to which reference has been made, did not take place solely while the rock was in the form of an uncrystallized or glassy magma. They continued during crystallization, and in many cases after crystallization was well advanced, but before complete consolidation of the rock. . . . The present structure has not only been determined by the rise of the magma but by a tangential pressure acting in a northwesterly and southeasterly direction.

Foye ('16) has suggested that the domelike character and quaquaversal dips of gneissic areas in the Haliburton-Bancroft area were produced by concordant injection of granite magma along a fissility in rocks of the Grenville series, originating at certain definite points, sending offshoots between successive layers, and giving rise to a pine tree structure. This hypothesis does not seem applicable to the Adirondack bodies under discussion. The evidence here all

points towards the idea that the magma was intruded during mountain-folding and itself subjected to great tectonic stresses.

Wilson ('18, p. 103, 137) wirtes of the gneissoid Precambrian intrusives of Timiskaming County, Quebec, as follows:

> The study of the structure of the banded gneisses indicates that they have been folded in a manner very similar to that exhibited by deformed sedimentary rocks. Though the bands are not continuous over wide areas like sedimentary beds, yet all the various types of folds are present on a small scale, and, in places, anticlines and synclines, nearly a half mile in cross section, can be recognized. These folds are generally pitching and, since the strike of the bands is dominantly in a southwesterly direction, it is inferred that the banded gneiss has been folded into pitching anticlines having a southwesterly trend . . . the belt of banded gneisses has a geanticlinal relationship to the adjoining belts of surface rocks . . . it seems evident that the rocks composing the belt of gneisses were subjected to mountain building stresses during their consolidation. . . . As a result of this action the solidified portions of the magmatic mass would presumably be broken up and the residual fluid magma of slightly different composition squeezed out to fill the fractures around the broken fragments and the variations in the complex produced in this way would then be flattened by deformation into banded gneiss. During the later stages of deformation the intrusions of igneous material from the interior of the massif would probably follow the planes of foliation and banding and thus develop a banded structure by lit par lit injection. As deformation continued, the banded gneisses produced in these various ways would no doubt behave very much like sedimentary strata and crumple into anticlinal and synclinal forms.

In the Grenville subprovince of the Canadian shield north of the St Lawrence, Wilson ('25) refers to many of the granite masses as sills or phacoliths the forms of which have been determined by the folding, and shows an areal map (p. 398) of a synclinal "phacolithic-like" mass of granite.

Among the various ideas expressed regarding the mechanics of intrusion of the Precambrian magmas under discussion, the writer is in accord most closely with those of Wilson and Bowen.

The phenomena of the Adirondack massif summarily described on a previous page are similar to those of the intrusive masses in the Grenville belt of the northwest Adirondacks, greatly complicated and modified, however, by the very much larger bulk of igneous material and the relatively very much smaller proportion of metamorphosed Grenville sedimentary material. Granite, with a little monzonite, averages about 30 per cent of the total area in the Grenville belt of the northwest Adirondacks, and the igneous rocks of the Rossie sill complex average 50 per cent, whereas the monzonitic-granitic intru-

sives of the great Adirondack body average about 80 to 85 per cent of the area, so far as can be judged from published maps.

The question arises as to whether the interpretation of the mechanics of intrusion adopted for the granite intrusions of the Grenville belt, modified to accord with the quantitatively different conditions, is applicable for the whole intrusive mass of the Adirondacks.

In discussing the foliation of the granite-monzonite rocks of the Lake Bonaparte and Lowville quadrangles, Buddington ('19) differentiated two masses, called respectively the Diana and the Croghan, each showing wide variation in composition. The rock of the Diana mass is characteristically porphyritic, and shows either protoclastic or cataclastic structures. The rock of the Croghan mass is equigranular and the texture is that due to direct crystallization from the magma without crush phenomena.

The Diana mass is five to nine miles wide in the Lake Bonaparte area, widening toward the southwest and pinching out to the northeast. Its structural relations can be satisfactorily interpreted as a close-folded composite laccolithic sheet, which pinches out to the northwest as a number of sills in the Grenville limestone, where both the Grenville beds and the igneous sills are thrown into a series of folds overturned towards the southeast. The strike and dip of the foliation in the igneous rocks underlying the west half of the Lowville quadrangle indicate the nose of a great anticlinal structure plunging about 45° ENE. Around the axial portion in a belt several miles long and as many wide, the strike is northwest and the dip northeast. All the rocks of this belt show a pronounced pitch whose azimuth varies from N 50° to 80° E, in accord with the direction of the axial plane of the fold. Included bands of Grenville metamorphic rock locally show crenulations with a similar pitch.

The maximum thickness for the Diana sheet exposed on the Lake Bonaparte and Lowville quadrangles seems to be about 25,000 to 30,000 feet. This is but little over twice as thick as the granites on the nose of the outer shell of the Canton phacolithic complex. The actual thickness may be less, due to minor folds.

The geographic limits of the Croghan composite mass are not known. It is probably somewhat younger than the Diana body. On the Lowville sheet, the structure of the foliation and included shreds of Grenville formations indicate a series of folds, closely compressed with steep dips in the northwestern part of the area, and open with moderate dips of 30° to 35° on the limbs in the southeastern portion of the quadrangle. In the southwest part of the number 4 quadrangle, the strike of the foliation can be traced, outcrop by outcrop,

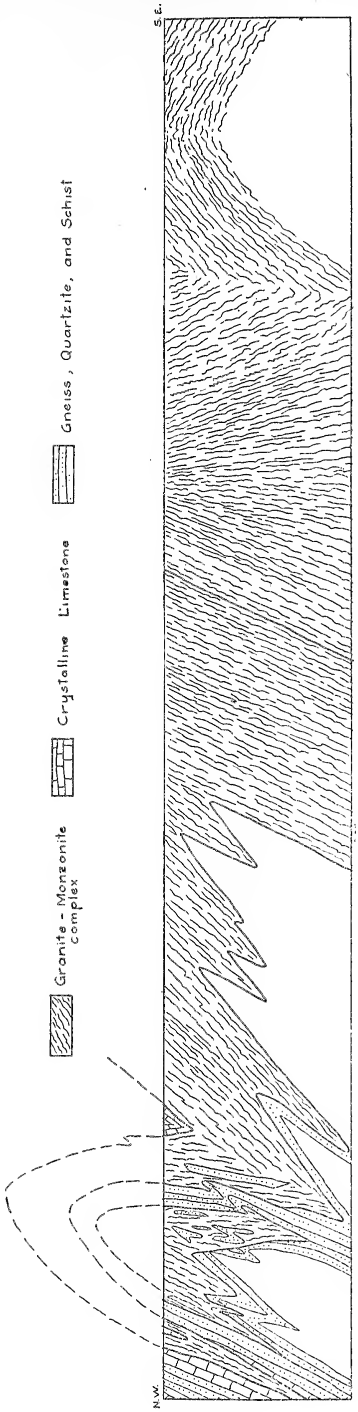



Figure 45 Diagrammatic sketch of foliation structure of granite-monzonite complex across Lake Bonaparte and Lowville quadrangles.

through an arc of 180° around the nose of an anticlinal axis plunging 30° NE, with the limbs dipping 30°–40° to the northwest and southeast respectively.

So far as micro-structure is concerned, the rock of the northwest half of the Diana mass shows cataclastic, and the southeast half protoclastic, phenomena. The rock of the Croghan mass, on the other hand, shows neither, but the minerals interlock as though directly crystallized from the magma. This suggests very strongly that the Diana mass is older than the Croghan body.

A generalized section of the Diana and Croghan masses exposed on the Lake Bonaparte and Lowville quadrangles is shown in figure 45.

On the Port Leyden sheet, to the south of the Lowville area, Miller ('10, p. 36–37) has described belts of rock with silimar strike but alternating direction in the dip of the foliation, and refers to it as "good evidence of distinct folding of the Precambric rocks on a large scale." Miller ('17, p. 40–41) has also described with considerable detail the domical character of the foliation of a syenite-granite body (Panther-Snowy Mountain mass) in the central part of the Adirondacks on the Blue Mountain and Indian Lake quadrangles. This mass is reported to be probably almost completely surrounded by a belt of Grenville strata "whose strikes and dips show it to lap upon the flanks of the great igneous mass." In conclusion, Miller writes: "We here appear to be dealing with something of the nature of a laccolithic intrusion."

As previously stated, Miller strongly advocates the hypothesis that there has never been intense folding of the rocks forming the main body of the Adirondack area, and that the disturbance of the Grenville is largely the result of thrusts attendant upon the intrusion of the magmas.

Alling ('18, p. 127) and Newland ('08), however, find close isoclinal folding on the east side of the Adirondacks, and the writer believes that tangential forces of considerable magnitude must have acted on all of the rocks of the Adirondacks, although perhaps with less intensity in the areas discussed by Miller.

We thus arrive at the following hypothesis of the mechanics of intrusion for at least a considerable part of the great monzonite-granite mass of the Adirondacks, disregarding the anorthositic body and any older intrusives. Magma, throughout a long interval of the early and intermediate stages of a period of orogenic revolution, was intruded into the Grenville formations in sill, laccolithic, and phacolithic forms, modified by some crosscutting. The earlier intrusions were subsequently folded and locally thrown into over-

turned folds by continued deformation. The later intrusions were subjected to stresses but to a smaller degree. The Grenville formations were to some extent split into thin leaves, kneaded and torn into shreds, or disintegrated and completely replaced or assimilated by the magma and its volatile constituents. Much brecciation, side thrusting, uplifting and general disturbance of the Grenville formations were caused by the intrusion, in addition to that caused by the orogenic stresses although the magmatic pressures themselves are attributed indirectly to the tectonic forces. Successive intermittent intrusions of magma differing in composition, and magmatic differentiation by deformation as advocated by Bowen ('20), may have played the major roles in producing the wide variation found in the rock facies.

A mass such as that under consideration would be of composite origin, for there is very definite evidence of an older gabbro intruded by monzonite and granite, of granite intruding hornblende monzonite, of a younger gabbro intruding the monzonite-granite rocks, and of abrupt contacts between other facies of the mass. Some of these intrusive relations would arise from differential movements of crystalline and liquid matter within the sheet, but the writer believes that in part it represents intermittent intrusions from the outside extending over a considerable time period. The data are inadequate for a thorough knowledge of the variations in the microscopic structure of the igneous mass, but that information available suggests belts of rock with alternating protoclastic and normal crystallization structures, and locally wide bands of rocks which are mashed and show cataclastic effects. Frequently on the Lowville and Lake Bonaparte quadrangles the writer has found the foliation of dikes, including pegmatite dikes, to be parallel to the foliation of the igneous country rock, even where the dike is at an angle to the foliation of the enclosing rock. These phenomena all suggest strong tangential pressures from the outside, extending over a long period of time and in part continuing after the cessation of intrusion, but probably to a much smaller degree. In the early stages the Grenville formations were the major factor in carrying stress and controlling the folding; in the intermediate and later stages the completely, or largely, crystallized portions of the earlier intruded magma acted like beds in undergoing folding, as suggested by Wilson. The folding probably varied locally in intensity and may have been less pronounced and of a more open type within the body of the Adirondacks. The whole process would be infinitely more complicated than the simple outline given.

The ideas as to the mechanics of intrusion of the monzonite-granite body of the Adirondacks here set forth are in conflict, at various points, with those expressed in previous publications on Adirondack geology; and the writer presents them not as a solution of the problem but simply as an hypothesis to be considered and tested by other workers for its validity of application to those portions of the Adirondacks with which they are familiar, and to the problem as a whole.

## ORIGIN OF PYROXENE GNEISS AND AMPHIBOLITE LAYERS

The origin of black layers of pyroxene gneiss and amphibolite, within and at the border of the granite masses, has been the cause of much discussion. Adams and Barlow ('10, p. 87–127) ascribe the formation of ferromagnesian gneisses in such an association of intrusive granite and limestone to the transfusion into the limestone of exhalations from the granite magma. Cushing accepts the idea of Adams and Barlow that limestone may be thus replaced by black ferromagnesian gneisses, and applied it to the occurrence of pyroxenic gneiss and amphibolites in the granites of the Adirondacks. Martin, however, on the Canton quadrangle, failed to find sufficient evidence of transition between amphibolite and limestone, or of the formation of amphibolite at the contact between granite and limestone, to warrant the assumption that the abundant layers within the granite masses were formed by a process of replacement of included limestone layers. He suggests that the pyroxenic gneiss and amphibolite layers are included bands of altered gabbro, which often occur as sills in the limestone.

The writer follows Adams and Barlow, and Cushing, in interpreting the pyroxenic gneiss and amphibolite layers as resulting from the replacement of limestone bands. Sills of gabbro are common in the limestone belt of the northwest Adirondacks, but the writer has at no place found a gabbro sill in such association with one of the granite phacoliths that it could reasonably be considered as the source of the black gneiss inclusions in the granite.

Most of the granite masses under discussion occur wholly within limestone, yet within the granite itself there are no inclusions of limestone, but only layers of pyroxene gneiss or amphibolite. The layers of limestone and associated rocks, which separate the inner and outer shells of granite in such compound phacoliths as the Gouverneur and Reservoir Hill bodies, are themselves partially replaced by pyroxene and hornblende gneisses. Furthermore, within

the outer shell of the Canton phacolith, northwest of DeKalb Junction where the limestone belt terminates against the granite, a number of bands of ferromagnesian gneiss are found along what would have been its former extension. About four miles northeast of Gouverneur is a small sill of granite which is intrusive into limestone, and which contains a multitude of small shreds of black gneiss, but no limestone. There seems to be no escaping the conclusion that the pyroxene and hornblende gneiss layers represent metasomatically replaced limestone layers. The problem arises as to whether the replacement was effected mainly by magmatic vapors or by a volatile-rich portion of the magma, or by solutions residual from the crystallization of the major portion of the magma. The ferromagnesian gneiss layers are often free from pegmatitic or quartz vein injection, and are in part disintegrated and replaced by granite as distinct from pegmatite. The replacement seems therefore to have been accomplished before the completion of the intrusion and consolidation of the magma.

The hypothesis of Adams and Barlow that the ferromagnesian gneisses were formed by the transfusion into the limestone of exhalations from the granite magma involves the idea that quantities of such substances as silica, alumina, the oxides of iron, magnesia, alkalies, and a small quantity of titanium, may, under magmatic conditions, exist in the form of volatile compounds and be transferred in the vapor phase in such quantities as to replace included layers of limestone at an early stage in the consolidation of the granite. This explanation, although thus involving quantity transfer in the vapor phase, seems well adapted to explain the field relations.

The hypothesis that the replacement of the limestone was effected by residual solutions avoids the necessity of so great a transfer of normally non-volatile compounds in a vapor phase, and is in keeping with the fact that in many cases of contact metamorphism the replacement is known to have been accomplished at a late stage of consolidation of the magma, since both the intrusive and the country rock are affected. In the case of the pyroxene and hornblende gneisses, however, no evidence has been recognized of alteration or veining of the adjoining granite, such as might be expected to have taken place if the transformation of limestone to black gneiss had been effected by residual solutions. This hypothesis can not be ruled out however by the evidence at hand.

In a different connection, but bearing on the same general problem, Fenner ('14) has suggested that the country rock might be rendered susceptible to permeation by magmatic solutions with an unusually high volatile content, through the advance action of the

volatile phase itself. The difficulty with the application of this idea is that the granite magma most probably was not of a composition to result in the transformation of limestone to ferromagnesian gneiss without assuming either an unwarrantable free flow of magma through the rock layer undergoing alteration, or the aid of quantities of volatiles. In much of the distinct amphibolite layers there are none of the typical granitic minerals, such as quartz, microperthite, or oligoclase, such as might well be expected if the granite magma had penetrated the limestone layers. The disintegration and replacement of the ferromagnesian layers by granite, however, very probably was accompanied by a process such as that outlined by Fenner.

It thus seems that the replacement was completed before the complete consolidation of the granite. It is recognized, however, that the rock disintegrated and brecciated by the granite might have been the limestone instead of the ferromagnesian gneiss, and that replacement was accomplished later by vapors and residual solutions.

## ORIGIN OF GARNET-SILLIMANITE GNEISS

Attempts to solve the origin of the garnet-sillimanite gneiss are hindered by the fact that much of the contact zone beween the granite and limestone is covered, and that critical contacts between the gneiss and the other rocks are usually poorly exposed or covered.

The contact zones are locally absent, and granite has been observed at several localities in direct contact with limestone; but at least a local contact zone of amphibolite and garnet-sillimanite gneiss has been found in association with every phacolith of granite in the limestone.

The origin of the garnet-sillimanite gneiss presents many very puzzling features, and many different ideas have been expressed regarding it.

The garnet gneiss of the Pyrites granite mass has been described by Martin as probably due to the fortuitous intrusion of the magma into a bed of garnet gneiss of metamorphic-sedimentary origin. Smyth and Buddington in their report on the Lake Bonaparte quadrangle noted that the garnet-sillimanite aureoles around the fine-grained granite masses were of common occurrence, and thought it highly improbable that at so many localities the granite masses could have sought out a bed of garnet gneiss intercalated in limestone and risen along it so as to yield the relations observed. They write: "A more probable explanation is that the garnet gneiss is the result of intrusion of the granite between beds of the Grenville series; a partial reaction at the borders between the granite and the aluminous and quartzose schists to produce the garnetiferous and sillimanitic

gneiss, and a contact metamorphism of carbonate beds to pyroxene or amphibolitic gneisses." They assumed that the local abundance of sillimanite in the garnet rock was of itself sufficient evidence that the granite must have reacted with aluminous sediments.

Cushing mapped a narrow band of garnet gneiss and associated amphibolite along the east side of the Reservoir Hill granite mass, and ascribed it to contact metamorphism.

Bain ('23) has described the formation of almandite and almandite-sillimanite bearing rock through replacement of limestone by solutions genetically connected with a Laurentian granite batholith in Chatham Township, Ontario, Canada. He finds that (1) crystalline limestone; (2) diopside, wollastonite, skarn rock; (3) feldspar, garnet rock; (4) biotite, garnet gneiss, with a little sillimanite; (5) biotite gneiss; and (6) a granite gneiss, show a zonal arrangement, and believes that each type of the series, in order, represents a more advanced stage of metamorphism. Concerning their origin, he writes:

The changes after the formation of a zone are due to the extension of the contact effects farther into the limestone and a burial of the old zone in a new one. Each succeeding zone (outward from the granite mass) is enriched in those constituents in which the preceding one is impoverished. Pegmatization and replacement were the agents that changed the rock. Replacement is important in the garnet zones, recrystallization in the biotite gneiss zone, and pegmatization in the granite gneiss zone. All the processes more or less overlap.

The conditions of formation of the almandite rock described by Bain, and its relations to the granite, however, are somewhat different in detail from those of the Adirondacks, though similar in principle. The almandite rock represents, according to Bain, the addition of silica, alumina, and iron to limestone by solutions that originated in the magma and traversed a biotite gneiss. The latter is itself supposed to have resulted from the alteration of an earlier formed band of garnetiferous feldspar rock. The composition of the almandite is almost the same as that of the almandite from the California aureole described in this paper.

Adams and Barlow ('10, p. 170–72) mention the occurrence of an amphibolite composed of garnet, gedrite and cordierite, with a little quartz, biotite, iron ore and rutile that formed from the extreme alteration of limestone by Laurentian granite. The cordierite contains inclusions of sillimanite. The composition of the garnet is not given.

Sillimanite and almandite are two minerals which in association are normally taken to suggest a derivation from aluminous sediments.

The local association of graphite still further tends to confirm such an origin. The natural deduction as to the origin of the garnet-sillimanite gneiss, therefore, would be that it represented metamorphosed sedimentary beds of the Grenville series, as has been suggested by Martin ('16) and by Newland (Cushing and Newland '25, p. 85). But when it is realized that in the case of 11 granite masses which are intrusive into limestone, the garnet-sillimanite bands are almost exclusively restricted to within a couple of hundred feet of the contact of limestone and granite, that for the most part no aluminous-siliceous beds suitable for recrystallization into garnet-sillimanite gneiss occur within the limestone, and that there are no bands whatever within the granite masses suggesting derivation from argillaceous or siliceous sediments, this hypothesis is seriously weakened. For over 90 per cent of the total length of the contact zones, the observed or confidently inferred country rock is limestone. A thick formation of garnetiferous gneiss is characteristic of the Grenville series of the northwest Adirondacks, but beds of such gneiss do not occur within the great limestone belts, except locally or interbedded with limestone in the transitional zone between the two formations, or where infolded. Wherever the granite is intrusive into argillaceous or quartzose sediments, there are abundant inclusions to indicate this fact; so that their total absence from the granite masses intrusive into the limestone has a positive significance. Martin speaks of the granite intruding the peripheral garnet gneiss and ripping off slabs of it, but the writer nowhere found positive evidence of such phenomena. The bands of garnet gneiss and granite are parallel, although with sharp contacts, and the relations are not such as one might expect were the granite intrusive into a bed of metamorphosed sediment.

The garnet-sillimanite gneiss is always intimately associated with pyroxene and hornblende gneisses, and often the garnetiferous gneiss appears to include narrow layers of the ferromagnesian gneisses and to break across them with narrow dikes, in the same fashion as does the granite. The question therefore arises as to whether the garnet-sillimanite gneiss could have arisen as a result of reaction of granitic solutions with the dark gneisses.

A part of the garnet-sillimanite gneiss appears to be certainly the result of the injection and alteration of the ferromagnesian gneisses by pegmatitic solutions, as is the case along the northwest side of the Gouverneur phacolith, the north side of the DeKalb phacolith northeast of Eddy, in the reentrant of the Pyrites mass, and at the south end of the Hyde phacolith. This type of gneiss has an inhomogeneous appearance due to residual small relic shreds of the

altered original rock, and to this extent has a different appearance from much of the garnet-sillimanite gneiss, which has a surprisingly uniform character. It may be argued that this uniformity is merely a later stage in the alteration of ferromagnesian gneisses and that all the contact garnet gneiss has had a similar origin.

Most of the garnet-sillimanite gneiss, however, as around the California mass and in the inner zone of the Gouverneur phacolith, is cut by many pegmatite veins and is therefore of earlier origin than the stage of pegmatite development during the consolidation of the granite. This raises the question as to whether it may be due to reaction of granitic, as distinguished from pegmatitic, solutions with the ferromagnesian gneisses. Amphibolite or pyroxene gneiss layers are common throughout the cores of most of the granite phacoliths, varying up to 20 per cent in volume; but nowhere except at the borders of the granite masses is there any development of garnet-sillimanite gneiss. Furthermore, bands of such gneiss occur interleaved with limestone, often apparently without being in contact with ferromagnesian gneiss. Again, the garnet-sillimanite gneiss does not normally contain residual relics of pyroxene or hornblende, as might be expected if it were disintegrating and reacting with the ferromagnesian gneisses. Despite these objections, the impression still remains that the development of the garnet-sillimanite gneiss is at least indirectly connected with the association of ferromagnesian gneisses.

The idea that most of the garnet-sillimanite gneiss along the contacts of granite phacoliths in limestone is a facies of the granite developed at a period in the consolidation later than the metasomatic replacement of the limestone layers by ferromagnesian gneiss and earlier than the pegmatite stage will next be considered.

The presence of high temperature fissure veins, with excellent symmetrical mineral banding parallel to the walls, shows that the overlying rock pressure may locally have been only moderate and have permitted the development of a vapor phase within the magma. Volatile constituents, such as those which were active in the replacement of limestone layers by amphibolite, and which may have been concentrated to some extent by partial crystallization of the magma, would migrate to the borders of the granite phacoliths, and either precipitated or reacting there might well produce a peculiar facies of the granite. The granite magma may have been unusually high in volatiles as suggested by the peripheral contact zones, the great quantity of pegmatite injected in the country rock, and the vast quantity of silicates introduced into the crystalline limestone. The medium to fine grain of the granite may be due in part to the escape of vapors

during consolidation. The vapor pressure may well have been high enough to induce vesiculation, and deformation might aid in squeezing the bubbles towards the periphery. It is certain also that considerable quantities of amphibolite were replaced by granite, and the material thus brought into solution must have been carried to or outside of the borders of the granite mass, for the granite is affected by assimilation only very locally immediately adjacent to the residual layers of amphibolite. The writer has seen no evidence at the bottom of the granite masses, or at the surface of amphibolite layers which might form false bottoms, that the removal of the compounds of iron, magnesia and lime were effected by sinking crystals. Consequently we are forced to the conclusion that such transfer must have been affected by volatile constituents, and thus yielded an additive effect to those contributed directly by the magma. The volatile constituents flowing through a partially consolidated sheet of magma might react with and attack the crystallized minerals, resulting in some of the replacement effects which are seen in thin sections of the almandite-sillimanite facies.

Within the cores of most of the granite phacoliths the major accessory mineral of the pegmatite veins is magnetite, whereas in the contact zones it is tourmaline. The tourmaline usually occurs in association with quartz as segregations or veins. The common presence of tourmaline in the pegmatite veins of the contact zones, as distinguished from those of the core, indicates a concentration of volatile constituents in the border portions during this stage. Tourmaline is essentially a borosilicate of alumina, ferrous iron and magnesia, and represents a concentration of the same elements as in the garnet-sillimanite gneiss, with the exception of boron. Locally, although not often, the pegmatite veins of the contact zones themselves carry up to 20 per cent of almandite.

If the garnet-sillimanite gneiss formed from a volatile-enriched magma, the latter must have undergone considerable local movement subsequent to its formation, as indicated by the present relationships of the gneiss, amphibolite, granite and limestone.

There is still another possibility for the origin of the garnet-sillimanite gneiss, namely, that it was formed by late-stage hot solutions reacting with and replacing solidified sheets of granite in the border zone.

There is very positive evidence that the very common, and often abundant, tourmaline has thus been introduced, for it can be definitely traced to association with fractures or with crosscutting pegmatite or quartz-tourmaline veins. But there is no evidence whatever that

the formation of the garnet or sillimanite was in any way connected with fractures or veins or was introduced as a result of replacement of solid rock by hot solutions.

The significance of the individual minerals, almandite, sillimanite and graphite needs further discussion with respect to their indications as to the origin of the gneiss.

Kemp ('12) has shown that the garnets usually found in limestone contact zones are nearly limited in composition to a range between the andradite and grossularite molecules. The writer knows of no occurrence of andradite along the contacts between granite and limestone in the northwest Adirondacks, though it has been found here at the contact between gabbro intrusives and limestone. Almandite (Heritsch '27; Eskola '21) with less than 4 per cent spessartite molecule characteristically occurs in chlorite and mica schists, amphibolite or hornblende gneisses, and injection gneisses. Garnets with a considerable to high spessartite content are characteristic of pegmatitic or aplitic facies of granite. Tilley ('26 p. 47–50) has suggested that MnO promotes the formation of garnet in contact zones of pelites, and that ordinary almandite is absent from normal pelitic contact aureoles. The spessartite molecule is very low in the almandite of the zones under discussion, and therefore will not explain its development here.

An alternative is to consider that it is formed at a lower temperature in the periphery of the granite magma than is characteristic of zones formed in the upper temperature ranges of contact metamorphism. Such a relatively low temperature for its formation might be brought about through a concentration of volatile compounds and a consequent lowering of consolidation temperatures. The association of almandite with the pegmatite fissure veins in the contact aureoles is evidence of its formation at low magmatic temperatures, without any relation to recrystallization of argillaceous sediments. Almandite is also a very common mineral in pegmatite veins which have been injected into mica schist, where it is the result of some such general reaction as biotite plus quartz equals almandite. Such garnetiferous injection gneisses are very abundant in the northwest Adirondacks and a small part of the garnet gneiss is very probably of such origin. The formation of the ferrous iron almandite from the ferric iron biotite implies a slight reduction of the iron. Similarly, the formation of almandite, instead of the ferric iron andradite, in association with limestone, implies a neutral or reducing atmosphere. Butler ('23) has suggested on the basis of experimental data, that

at the usual temperatures of contact metamorphism $CO_2$ may be most effective as an oxidizing agent, its activity decreasing at both higher and lower temperatures. He thus explains the common occurrence af andradite in contact zones. The range of temperature under which the almandite rocks here described were formed appears to be similar to that at which at least some andradite zones have formed. This would necessitate that there should have been a smaller concentration of $CO_2$ than usually developed in the almandite contact zones, or that the magmatic solutions and vapors themselves were of unusual character and in sufficient quantity to dominate the direction of chemical reactions. The latter alternative seems preferable.

Sillimanite is very rarely ascribed to magmatic solutions, except in connection with assimilation of argillaceous sediments. It has been previously noted, however, that Bain has described an almandite-feldspar rock with a little associated sillimanite replacing limestone, and that Adams and Barlow have described the replacement of limestone by gedrite and sillimanite. Adams and Barlow ('10 p. 127–39) have also described a granite intruding amphibolite which is locally full of small nodules. These nodules consist of quartz, sillimanite, muscovite and black tourmaline, with a varying amount of plagioclase and an untwinned feldspar, perhaps orthoclase. They write of their origin as follows:

The possibility of the nodules having been produced by the melting down of portions of some fibrolitic band in the wall-rock is eliminated by the fact that not only are such bands not found in the wall-rock, but also by a zonal arrangement often observed in the nodules and their passage into the indistinctly banded veinlike forms. . . . The study of this occurrence shows that contemporaneous veins of an acid character may be formed, not only during the final stage of crystallization, as in the case of the heterogenic schlieren . . . but that highly siliceous portions are sometimes segregated or differentiated out of a granite magma before crystallization.

The presence of graphite in some of the garnet-sillimanite gneiss is not of itself proof of a sedimentary origin, for many of the intrusives in the northwest Adirondacks, where in contact with limestone, contain disseminated flakes of this mineral.

None of the hypotheses discussed for the origin of the garnet-sillimanite gneiss is satisfactory. Undoubtedly more data bearing on this problem will be found when the country north of the St Lawrence is studied in detail. Tentatively, the writer favors the idea that it is formed essentially by granitic solutions peculiarly rich in volatiles or traversed by a relatively free flow of volatiles, and indirectly due to association with and assimilation of amphibolite bands.

## OTHER TYPES OF CONTACT METAMORPHISM

On the Lake Bonaparte quadrangle, just southeast of Lake Bonaparte, is a body of the fine to medium-grained granite, intruded into argillaceous and quartzose beds. The latter have been permeated throughout by granitic solutions, and the major minerals in the argillaceous and quartzose rocks of the contact aureole here are microperthite, quartz, cordierite, sillimanite, biotite and garnet, with locally a little spinel and plagioclase and a trace of corundum. Interbedded calcareous rocks have been altered to the usual pyroxenic rocks with diopside, enstatite, hornblende, plagioclase or scapolite, and locally quartz, as the major minerals. Enstatite and cordierite have not been found together in the same rock.

In the noncalcareous beds near the contact with the granite, and in blocks included within the granite, cordierite is a major mineral and equal in importance to garnet. In some included blocks garnet may be wholly lacking. Tilley ('26, p. 47–50) has suggested mandite is absent in normal contact aureoles, unless it is a spessartite-bearing type, and cites E. B. Bailey as having convincingly demonstrated that in the Ben Cruachan aureole cordierite hornfelses have been developed from garnet-bearing schists, the garnet being replaced by and converted into pseudomorphs or cordierite and magnetite. He contrasts the contact aureoles of Kristiania and Comrie, in which cordierite, potash-feldspar and magnetite are abundant to the exclusion of white mica, with certain contact aureoles in the British Isles, in which garnet is a conspicuous and significant mineral and in which there is a paucity of potash-feldspar but abundant micas; and suggests that the cordierite-bearing aureoles were formed under relatively dry conditions, and the garnet aureoles in a relatively wet environment. The explanation for the Clark Pond cordierite aureole is not clear, but it seems as if the composition of the country rock must have played an important part, and perhaps higher temperature conditions.

The Edwards compound phacolith is bordered by a garnetiferous injection gneiss with intercalated layers of amphibolite, the former probably resulting from the recrystallization of argillaceous beds, presumably shales, and their permeation and injection by pegmatitic solutions, and the latter from the recrystallization and addition of magmatic material to impure intercalated limestone layers. A detailed description is given by Cushing (Cushing and Newland '25, p. 28–33). The gneisses consist of quartz, biotite, microperthite with some microcline, oligoclase and garnet. The derivation of garnet through re-

active replacement of biotitic schist by pegmatitic solutions is often very well shown.

Greenish pyroxene gneisses are the predominant country rock in the Butterfield Lake compound phacolith on the Hammond quadrangle, and also along and near the southeastern border of the Alexandria granite mass, where they have been described in detail by Cushing (Cushing and others '10 p. 47–50) and ascribed to the recrystallization of a belt of impure limestone, with much change by contact action and much material added by magmatic solutions, whose presence is indicated by abundant intrusive sheets of granite and veins of pegmatite. The manner in which the Grenville rocks are broken up and injected by the granitic magma and solutions suggests that they were originally siliceous and more brittle than the purer limestone beds. The occurrence of interbedded sillimanitic gneisses and quartzites also points in the same direction. On the Alexandria Bay quadrangle Cushing reports the gneisses to consist of pyroxene and feldspar, in part, and plagioclase (andesine-labradorite) and in part microperthite or microcline, with often some associated actinolite, quartz and calcite. Tourmaline, titanite, magnetite, pyrite, apatite and zircon are accessory minerals.

The gneisses associated with the Butterfield Lake phacolith are similar and, in addition to the usual bands of plagioclase and pyroxene, contain layers consisting of mixtures in varying proportions of plagioclase, pyroxene, hornblende, orthoclase, quartz and scapolite, and occasionally of orthoclase and hornblende. Scapolite rarely forms more than 10 per cent of the rock, although it is a common accessory. The pyroxene, or pyroxene plus amphibole, usually forms from 30 to 50 per cent of the rock. Quartz does not usually constitute over 15 per cent. Usually the pyroxene is a diopsidic one, but occasionally enstatite is found, possibly indicating original dolomitic beds.

Locally there are contact deposits of granulitic character consisting of pyroxene, microcline, and calcite, or of pyroxene and scapolite, or of pyroxene with about 30 per cent plagioclase. Wright ('23 p. 18–19) has also described metamorphic pyroxenite in association with the Alexandria granite mass consisting of diopside, which is usually the most abundant mineral, in association with albite, orthoclase and quartz in varying amounts. He ascribes it to recrystallization of a siliceous dolomite with the addition of magmatic material, especially the albite and orthoclase.

These pyroxene gneisses and granulites and the garnetiferous injection gneiss appear to have been formed largely at a late stage in

the consolidation of the granite by mineralizing solutions forming and accompanying the pegmatitic injection.

Throughout the limestones of the northwest Adirondacks, except in very local belts silicates such as diopside, scapolite, phlogopite, tremolite, hornblende, chondrodite, and tourmaline are locally abundant, have been introduced by solutions later in origin than the pegmatites, and indicate the addition of silica, alumina, magnesia, soda, and a little oxide of iron. Nodules of marialite or mizzonite, phlogopite and brown tourmaline are abundant locally. Boric acid, phosphorus pentoxide, chlorine and fluorine have also been added in small amounts. In the case of this mineralization, however, there is difficulty in deciding with which granitic magma the solutions producing it were genetically associated. It seems most probable, however, that a similar type of mineralization was genetically associated with both types of magma that gave rise to the two facies of granite in the region. A careful study of this mineralization has been made by Agar ('23, p. 129–30).

The writer has noted no evidence of the replacement of scapolite by feldspar; but the reverse process, the alteration of feldspar to scapolite, has been found in many specimens of amphibolite from the contact zones. The formation of scapolite from feldspar is accompanied by alteration of pyroxene to hornblende, and both types of metamorphism probably belong to a late stage, perhaps contemporaneous with the solutions which were later than the pegmatites and produced the widespread mineralization of the limestone. In some of the tourmalinized pegmatite veins, chlorite and muscovite are partially replacing the garnet, and are probably nearly contemporaneous with the tourmaline, as the latter is wholly unaltered.

The foregoing brief survey of several types of contact metamorphism has been given to show the kind of phenomena which in the northwest Adirondacks are associated with granite masses of interpreted as intruded in the form of phacoliths during a period of orogenic pressure.

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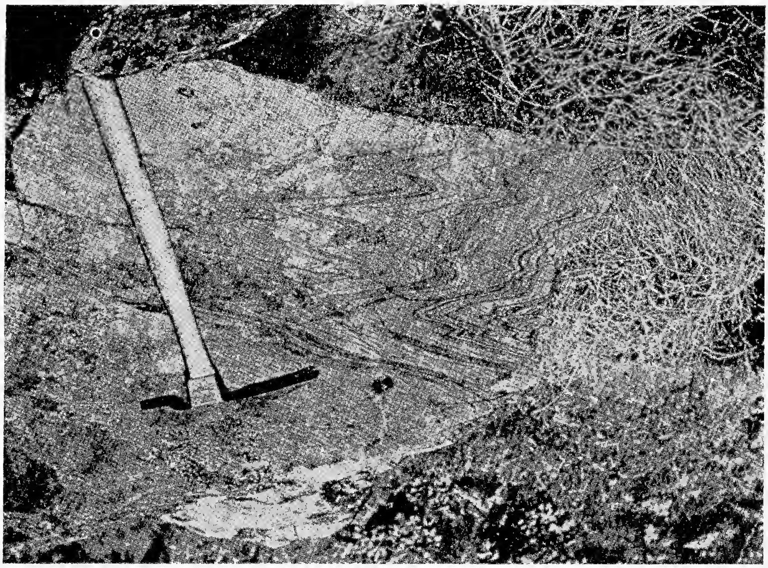

Figure 46 Interbanded granite and amphibolite of contact zone at NE end of Pyrites phacolith, Canton quadrangle. Strike of contact is NW. Crenulation is due to force along NW-SE lines. Photo by J. C. Martin.

Figure 47 Granite with included layers of amphibolite, thrown into folds by interaction of major NW-SE and minor NE-SW forces, Hyde School, Hammond quadrangle.

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